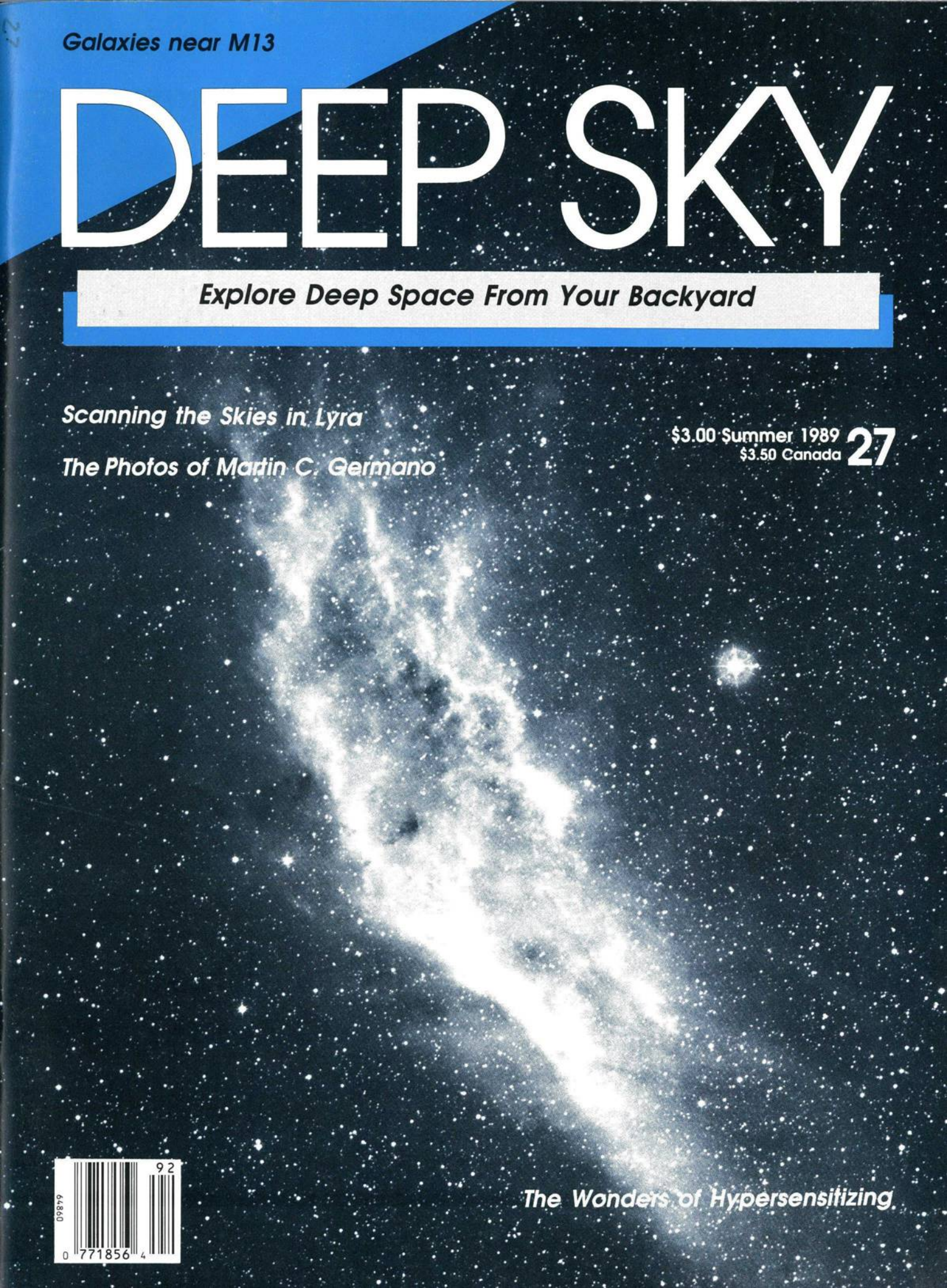
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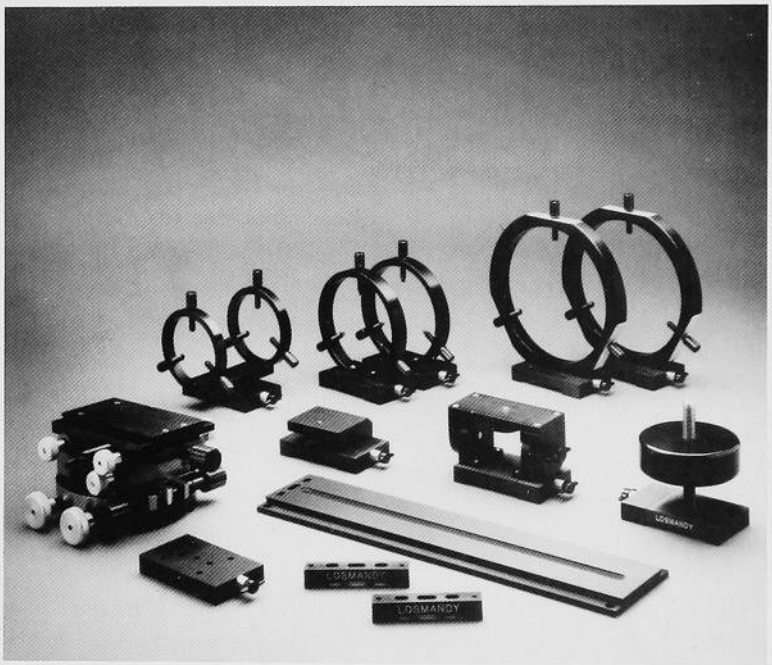

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DEEP SKY

THE MAGAZINE FOR DEEP-SKY OBSERVERS AND ASTROPHOTOGRAPHERS SUMMER 1989 VOLUME 7, NUMBER 3

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Opposite page: NGC 6979, central region of the Veil Nebula, photographed by Martin C. Germano with an 8-inch f/5 reflector, hypered Tech Pan, and a 65-minute exposure.

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At the Eyepiece
Poor, Misunderstood Lyra

Poor, misunderstood Lyra. Typically backyard astronomers only point telescopes at Lyra for a quick peek at the Ring Nebula or to see if their telescope can split Epsilon. Although the tiny, bright group of stars holds many other deep-sky objects, no one ever looks at them.

This issue's lead feature article by Brian Skiff takes you beyond the Ring Nebula to survey the lesser-known wonders of Lyra. You'll be surprised at the variety splendor of Lyra's many faint galaxies and gleaming double stars. You'll meet two other planetary nebulae and other assorted goodies. Brian's precise descriptions will guide you through hunting down all of these objects whether you have a small or large scope. Special thanks to Harold Corwin of the University of Texas for providing us with data for this article from the *Third Reference Catalogue of Bright Galaxies* (*RC3*), due out next autumn.

Sitting within Brian's article is Roger Sinnott's account of the origin of a magnificent new book called *NGC 2000.0*. This handy guide provides updated positions, magnitudes, and sizes for all NGC objects and should be placed on every observer's bookshelf. For an evaluation of this important book, see my review in the May 1989 ASTRONOMY.

Have you ever seen NGC 6207, the little galaxy near M13? It's a favorite object of mine, one I return to every summer. Surprisingly, NGC 6207 is not the only galaxy so close to M13. Robert Bunge's feature article describes a group of challenging galaxies all located within a few degrees of the great Hercules Cluster.

Astrophotography gets its share of the spotlight in Kim Zussman's beautifully illustrated article on the merits of hypersensitized Tech Pan film. If you're into shooting black and white, clearly Tech Pan is the way to go. Kim explains that the wonder film of the '80s is likely to remain the wonder film of the '90s. Also in this issue is a portfolio of spectacular new photographs by Marty Germano, Kim's down-the-street neighbor. Marty has succeeded in capturing on film some incredibly faint and legendary deep-sky objects. Not surprisingly, Marty also uses hypered Tech Pan.

Summer brings a fresh load of conventions, and I want to thank all of you who made Astrofest II in Hartford, my trips to Adler Planetarium, and the Texas Star Party a great pleasure. I look forward to meeting many more of you at the AAS Summer meeting in Ann Arbor, Michigan, this June; Stellafane in Springfield, Vermont, this August; and Astrofest in Kankakee, Illinois, this autumn.

About a month after you get this issue, Kalmbach Publishing Co., the company that publishes *Deep Sky*, will move from its downtown Milwaukee building to a new glass-and-steel building in Waukesha, Wisconsin (the western 'burbs). Effective July 1, 1989, our new address will be 21027 Crossroads Circle, Waukesha, Wisconsin, 53187.

Lastly, *Deep Sky Observing with Small Telescopes*, the book produced by the editors of *Deep Sky*, is finally published. Needless to say, we hope you'll dash right out and buy a copy as soon as you possibly can!

Yours truly,

Dave Eicher

Letters to *Deep Sky*
The Supernova in M66

The Supernova in M66

On January 30.5 UT, Reverend Robert Evans of Hazelbrook, New South Wales, discovered his eighteenth supernova. The first account is Evans' own description of the supernova sighting, forwarded by Steve Lucas of Midlothian, Illinois.

My first sighting of the supernova was on January 30.5 UT, when the supernova dimly glowed at magnitude 13.0. With my 16-inch telescope at 200x, the supernova was immediately obvious. It could even be seen at lower magnifications, although the galaxy was still fairly low in the sky. After checking Gregg Thompson's chart and estimating the supernova's position relative to the nucleus (15" west and 50" north), I rang Rob McNaught to see if there were any telegrams about a supernova in M66.

Rob went to the nearby Uppsala Southern Schmidt telescope at Siding Spring to make an exposure of the galaxy. While this was happening, I called Brian Marsden at the Central Bureau in Cambridge to see if any asteroids might be in the area of M66 — none were. Also, there had been no reports of a supernova.

An hour later, Rob called back and said his efforts to photograph the supernova had failed. He tried to record it without being able to see the object, and he had missed the field. Then the sky clouded over. All I could do was to leave a message on Carl Pennypacker's answering machine in Berkeley, California, and go to bed.

Just as dawn was breaking at Siding Spring, Rob was able to make a one-minute exposure of the supernova. With this photo, he confirmed the object and reported it officially to the Central Bureau. At the breakfast table I heard of the confirmation when Pennypacker called to say he had heard of the supernova from Marsden in Cambridge. An hour later, Rob called and told me he had photographed the galaxy during the last minutes of reasonably dark sky.

Robert O. Evans
Hazelbrook, New South Wales
Australia

Dear Dave / During the Winter Star Party in the Florida Keys, I had the good fortune to observe the supernova in M66 discovered by Robert Evans on January 30, 1989. I first spotted it early on Sunday, February 5th. Viewing through Tom Clark's magnificent 25-inch f/5 Tectron telescope, I saw M66 like never before. Surrounding the galaxy's core was a subtle spiral arm halo with one arm curving toward the south. The supernova appeared to glow at about magnitude 12.5.

According to Daniel W. E. Green of the Central Bureau, the supernova glowed at magnitude 13.0 at the time of its discovery. Since that time, it has brightened to between magnitudes 12.0 and 12.2, where it remains (February 14th).

Phil Harrington
54A Dillmont Drive
Smithtown, NY 11787

Dear Dave / For some time I have been looking for an area where amateur astronomers can really help professionals. Robert Evans' discovery of his eighteenth supernova has made me conclude that supernova searching is the right thing to do.

On the morning of February 11, 1989, I set up my scope and began observing with my friend Dale. We checked M65, M66, M105, NGC 2903, and NGC 3628. We used 6-inch and 8-inch reflectors and observed the galaxies simultaneously so we could talk about the stars we were seeing as we observed them. As I looked at M66 at 68x, I noticed a starlike object in one of the galaxy's spiral arms. Dale saw it too, and I proceeded to make a sketch of the galaxy.

My mistake was assuming

the object was a Milky Way foreground star. After all, what are the chances of finding an extragalactic supernova? After our observing session ended, I went home and compared the sketch with a Jack Newton photo showing M65 and M66. I was astonished to see no star in the photo, but still didn't believe the observed star could be a supernova.

Later that morning a friend called and told me about the supernova discovery by Reverend Evans. I had independently discovered the object two weeks after Evans, and that gave me the enthusiasm to begin an organized program of supernova searching.

Michael D. Petrasko
Box 1170
North Falmouth, MA 02556

Dear Mr. Eicher / No doubt you will be swamped with observations of the supernova in M66 over the coming weeks. Nonetheless, I wish to add my observation to the pile. I observed the supernova on February 11, 1989. As Leo rose from the east and the Moon's glow vanished in the west, I decided to observe the multitude of galaxies in and around the Virgo Cluster. When I moved to Leo and M66 I was surprised to see, at high powers, what appeared to be two nuclei!

The thought of a supernova crossed my mind, but I have never been that lucky. The next day I called the astronomy hotline of the Amateur Astronomers, Inc., at Union County College, where I learned of the supernova. It is the first such event I have observed.

Gordon Bond
313 Raphael Avenue
Middlesex, NJ 08846

Dear Dave / Amateurs rarely get the chance to observe a bright supernova. I receive the *IAU Circulars* (for our club, the Houston Astronomical Society), and have seen that the majority of supernovae peak at about 17th magnitude. In fact, I can remember seeing only two supernovae in the past five years. One was in NGC 5128, which I observed at the Texas Star Party in 1986. The other was a magnitude 16.5 object that Brian Skiff showed me at another TSP.

I was delighted when I heard about Reverend Evans' eighteenth discovery. Between February 10 and 12 the supernova glowed at about 12th magnitude, and I had the good fortune to observe it.

In searching through the literature, I've found precious little about amateur observations of extragalactic supernovae. I suppose the reason is that these objects have been considered too faint to be observed by amateurs. Or it could be that supernovae aren't exciting. As one of our club members said, "It looks just like a faint star." But what a star! For myself, the excitement of seeing a supernova comes in contemplating the awesome event represented by the object.

M66 lies at a distance of approximately 12 megaparsecs. The supernova's visual magnitude of 12 means that the object must have an absolute magnitude of -18.4, which falls within the predicted range for supernovae. At a distance of 10 parsecs, the supernova would shine with an intensity somewhere between the Full Moon (magnitude -12) and the Sun (magnitude -27). By comparison, the Sun at that distance would glow dimly at magnitude 4.8. And to think that by observing the supernova, we are looking at an event that occurred 40 million years ago!

Don C. Pearce
4917 Evergreen
Bellaire, TX 77401

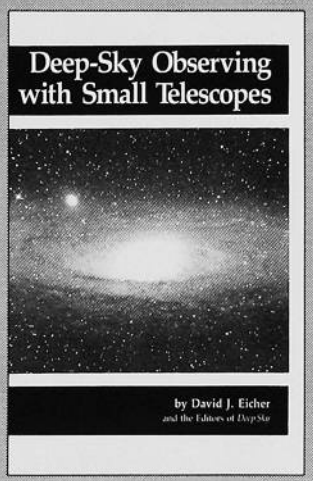
Messier Marathon Correction

Dear Dave / I caught a few errors in my article on the Messier Marathon in the Spring *Deep Sky*,.

The sweep for M95 should be 8.7° east instead of west. The sweep star for M104 should be Eta Corvi instead of Eta Virginis. The object identified as M30 in the middle section should be M39. The sweep star for M22 should be Lambda Sagittarii instead of Gamma Sagittarii. The north sweep for M54 should be 1.8° instead of 1.0°. The north sweep for M2 should be 4.8° instead of 4.0°.

T. C. Hoffelder
724 Vicksburg Avenue
Norman, OK 73071

Discover the Mysteries of the Cosmos with DEEP SKY OBSERVING WITH SMALL TELESCOPES
by ASTRONOMY's Assistant Editor David J. Eicher and the editors of* Deep Sky *magazine



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The *Other* Lyra

by Brian Skiff

Think of Lyra and you probably recall visions of the Ring Nebula, Epsilon's gleaming twin binary systems, or maybe the cascade of stars that makes up globular M56. It's hard to associate *galaxies* with Lyra. Galaxy viewing in Lyra is like skiing in sunny, hot Arizona: something that seemingly just can't be, but in both instances is very much the case. *NGC 2000.0* lists thirty-nine NGC and IC objects in Lyra, and all but four are galaxies. Lyra is indeed loaded with faint galaxies and other sights neglected by popular guides to the sky.

Surveying Lyra's Goodies

During the summer of 1988, I made a comprehensive survey of objects in the constellation. The basic list was composed of galaxies brighter than magnitude 13, the comfortable limit with my 6-inch refractor. To these objects I added two open clusters, the globular Messier 56, and three planetary nebulae (one a non-NGC object). The nineteen deep-sky objects were complemented with no less than sixty double and multiple stars, of which only the brightest and most interesting dozen are discussed here. The entire collection provides a complete assay of the brightest objects for instruments up to about 8-inches aperture and a sampling of the best for larger telescopes.

After starting on this project, Paul Brown mentioned during a phone call that he, too, had been working independently on the Lyra galaxies. He promised a set of drawings and descriptive notes of the objects, observed with his (then) new 16-inch Newtonian. Via Paul, Alister Ling heard of the project and has contributed observations made in 1984 and 1985 with 12:5-inch Newtonians.

Paul and Alister, working from eastern Canada, generally reached only half a magnitude fainter on stars than I did with my 6-inch from a demonstrably superior site outside Flagstaff, Arizona. However, they did record the galaxies as somewhat larger than I did because the 6-inch loses out in limiting surface brightness compared to the bigger instruments. Bearing these circumstances in mind, the observations should represent what you're likely to see from an average North American site.

In order to check the large number of details in and around the galaxies, clusters, and nebulae, I turned to the *Palomar Observatory Sky Survey* (*POSS*) prints. The orientations of the drawings, the distances and directions of stars, and many interior details of the nebulous objects — often fleeting at the eyepiece — could be verified using these photographs.

With the observations collected and analyzed, next came the data hunt. For all but a few of the galaxies the only published data are magnitudes from Zwicky's *Catalogue of Galaxies and Clusters of Galaxies* (*CGCG*) and sizes and types from the *Uppsala General Catalogue of Galaxies* (*UGC*) by Nilson. These data are subject to a variety of systematic errors, but can be corrected to a standard system.

I asked Harold Corwin of the University of Texas whether information on these galaxies from the upcoming *Third Reference Catalogue of Bright Galaxies* (*RC3*) might be extracted from their massive database. He responded with the data included in the accompanying table. For all the galaxies, then, we can present basic data on standard systems. Data for the other classes of objects come from a variety of sources, and although they are the best obtainable, they are not nearly as consistent overall as the data for galaxies.

None of the galaxies is a show-stopper, and only 11th-magnitude NGC 6703 can be called moderately bright. In his letter enclosed with the drawings, Paul wrote that he could not apologize for their lack of fine details: they "just aren't there." Instead, he noted, "Skilled observers will recognize the challenge each object presents from the sketch alone." Even so, one fact that lends observing interest is that all lie within 20° of the galactic plane in Cygnus. Thus, all are set in rich starfields, compared to what is normally found in the familiar, galaxy-rich spring constellations.

The night I spent on these objects gave me a real visual workout with the 6-inch, because they were mostly near the limit for this aperture. They're small, so don't be afraid to use fairly high power on them: up to 200x with an 8-inch scope and as much as 300x or so with a 17.5-inch instrument. I was able to spot the brighter galaxies at 50x in the 6-inch scope but was not able to get much out of them except at 150x or so, which is about the maximum power suitable for faint, extended objects at this aperture.

Exploring the Other Lyra

Once you begin to observe them, you'll see that the objects in Lyra present an incredible array of views. **NGC 6646** is the westernmost of a string of galaxies aligned east-west across the north side of the Lyre star pattern a degree or two above Vega and Epsilon. (Incidentally, many more galaxies are located along this strip besides the NGC objects plotted on *Uranometria*).

At 150x in the 6-inch, the glow from NGC 6646 was about 50" in diameter with a moderate concentration toward a relatively large, broadly brighter core. A very faint stellar nucleus was occasionally visible at the galaxy's center. Alister and Paul also saw the stellar nucleus, though in his 16-inch Paul found it "substellar," that is, nearly stellar. He also saw a fair degree of mottling and asymmetry in the distribution of light of the slightly elongated halo. Photographically, however, the spiral arms are quite smooth, as is typical for an early type spiral. In the same half-degree field are two fainter galaxies, **IC 1288** and **IC 1289**, the first of which, according to Alister, is easy in a 12.5-inch telescope.

Galaxy **NGC 6675** lies midway along the string of objects mentioned above, in this case nearly due north of Vega. My notes on N6675 start: "Damn! Glare from Vega off the diagonal mirror brightens the field at 75x." Even with the bad bounce of starlight I found the galaxy without difficulty 1.2' south of a 13th-magnitude star.

NGC 6675's moderately low

Known for the Ring Nebula, Lyra also holds faint galaxies. Within a field diameter or two of Epsilon Lyrae (bottom right) lie four galaxies. Photo by Martin C. Germano.

One of the frequently-observed objects in Lyra is M56, a small globular cluster finely captured in this photograph by Preston Scott Justis (10-inch f/6 reflector, 103a-O film, 40-minute exposure).

The Genesis of *NGC 2000.0*
by Roger W. Sinnott

Whether you're looking at galaxies in Lyra or any other deep-sky objects, a new guide can help. Called *NGC 2000.0*, it is the result of an evolutionary process of nearly two centuries. J. L. E. Dreyer published his *New General Catalogue* (*NGC*), the precursor of *NGC 2000.0*, 101 years ago this summer. Back then, photographing the sky was still a hit-or-miss, highly experimental pursuit. Almost all astronomical discoveries were made the old-fashioned way, by astronomers looking into an eyepiece.

In those days the world's largest telescope was Lord Rosse's 72-inch reflector at Birr Castle, Ireland, completed in 1845. The Danish-born Dreyer had spent the years 1874-81 as an assistant at Birr but found the 72-inch instrument too clumsy to troll effectively for new objects. Instead, Rosse's telescope mainly served to confirm and clarify discoveries made at other observatories. Much smaller apertures did the bread-and-butter work of astronomy in Dreyer's day.

The bulk of the *NGC*'s 7,840 nebulae and star clusters had been discovered by the Herschels between the late eighteenth and mid nineteenth centuries, working mostly with reflectors no bigger than 18-3/4 inches aperture. Because the speculum metal mirrors used by the Herschels are less reflective than modern aluminized mirrors, keen-eyed observers with 14- to 16-inch telescopes can probably see as much today. A few *NGC* discoveries came from other large scopes, such as the 26-inch refractor at Charlottesville, Virginia. But even that instrument's light grasp is matched by some of today's big backyard Dobsonians.

For plumbing the depths of space visually, the best amateur telescopes are now about equal to those in professional observatories of a century ago. So the idea to revitalize the *NGC* made a lot of sense. All the early visual descriptions are completely untainted by subsequent revelations of astrophotography and cosmology. Dreyer's "eF" (extremely faint), "gbM" (gradually brighter toward the middle), or "E ns" (elongated north-south) are often more helpful to a modern galaxy observer than knowing its integrated B magnitude or dimensions on the D_{25} system.

A computer tape of the Tifft-Sulentic *Revised New General Catalogue* (*RNGC*) was the natural place for our project to start. But we also wanted to add the two supplements to the *NGC*, together called the *Index Catalogue* (*IC*), which Dreyer brought out in 1895 and 1908. The *IC* includes the discoveries of pioneer astrophotographers like Max Wolf and E. E. Barnard.

Believing no computerized version of the *IC* existed, we hired Lenny Silverman of the Amateur Telescope Makers of Boston to input all 5,386 objects, positions, and descriptions from Dreyer's original — a two-month job he completed with great care in January 1988. Then we discovered that Robert S. Dixon and George Sonneborn had already included the *IC* in their *Master List of Nonstellar Astronomical Objects* (*MOL*), which we had on magnetic tape.

A waste of effort for Lenny then? No! It offered us the luxury of a very powerful cross-checking method, similar to the old days when navigational tables and almanacs were calculated independently by several people and results were compared to uncover arithmetic mistakes. Our computer, a DEC Micro/PDP-11, detected about twenty typos committed by Lenny and a somewhat larger number on the *MOL* tape (transposed digits, right ascensions off by exactly 1 hour, and so on). We then sent Dr. Dixon the printout of errors so he could update future versions of the *MOL*.

Armed with machine-readable versions the *RNGC* and *IC*, we now began to focus on the main problems: how to weed out *RNGC* errors (many of which have been pointed out in past issues of *Deep Sky* , and how to infuse modern magnitudes, angular diameters, and object types. No one in Dreyer's day knew the difference between a galaxy and a nebula, and some of the round ones were even called unresolved globular clusters!

First, we precessed the *RNGC*'s 1975.0 coordinates back to 1860.0, the equinox of the original *NGC*. We also converted all declinations into north polar distances, again to match Dreyer. Now we could begin to delve into a vast, almost untapped resource: errata lists compiled by Dreyer himself and included in the modern reprint of the *NGC* and *IC* (pages 237, 281-283, and 366-278) — over seven hundred errors and notes of all kinds. For example, the famous 10' error in the declination of the globular cluster Omega Centauri would never have found its way to the Becvar catalogue and *Norton's Star Atlas* if more heed had been paid to Dreyer's own correction, published back in 1908.

Next, the computer versions of the *NGC* and *IC* were precessed forward again to equinox 1950.0, the reference frame of most modern catalogues. We

The preeminent deep-sky object in the area is M57, the Ring Nebula in Lyra. A ghostly ring in small telescopes, it often shows an elusive central star to large scope owners if seeing and transparency are just right. Photo by Kim Zussman (11-inch f/10 modified SCT, hypered Tech Pan film, 20-minute exposure).

had magnetic tapes of these left over from the *Sky Catalogue 2000.0* project. By reading these tapes again, we were able to extract all objects with *NGC* and *IC* designations, not just those that had met the *Sky Cat* cutoff criteria. A newer, printed source also proved extremely helpful: Harold Corwin's *Southern Galaxy Catalogue* (1985).

Surely the procedure that will raise the most eyebrows is the one used to match *IC* objects with modern galaxies. Still working in 1950.0 coordinates, we had the computer look in the immediate vicinity of each *IC* position to see if the *MOL* tape showed a single galaxy (and not more than one) from a modern reference like the *Uppsala General Catalogue* or the *Morphological Catalog*.

All along we kept reminding ourselves that this was just the kind of data juggling that has spawned catch phrases like "garbage in, garbage out." So we proceeded cautiously indeed! In the end, we tentatively identified and found modern magnitudes and sizes for 59 percent of all *IC* objects.

Two other important resources were errata lists, mostly to the *RNGC*, kindly supplied by Brent Archinal and Brian Skiff. Throughout the preparation of *NGC 2000.0* we gave higher weight to errata lists than to mere catalogue entries. Anyone familiar with the drudgery of cataloging feels a special respect for the painstaking detective work that went into compiling such lists.

The very last step, of course, was to precess all positions to equinox 2000.0 and sort them by right ascension. Incidentally, throughout all this epoch-hopping our computer kept coordinates internally to 1" precision. Most positions are not actually known so accurately, but we did this to avoid any accumulation of rounding errors.

A look at the selected list of *NGC* and *IC* objects in Lyra shows many blanks and even questions as to what some of them actually are. Everything in the rightmost descriptive column is just as Dreyer wrote it, and chiefly of interest to deep-sky observers. Everything else should be in harmony with modern astronomical knowledge — gaps and all. I only hope *NGC 2000.0*, planned for easy use with *Sky Atlas 2000.0* and *Uranometria 2000.0*, can help observers and researchers start to fill in some of those gaps.

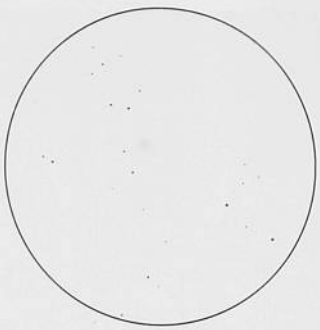
Roger W. Sinnott is editor of NGC 2000.0 *and associate editor of* Sky & Telescope.

Lyra Objects Selected from NGC 2000.0

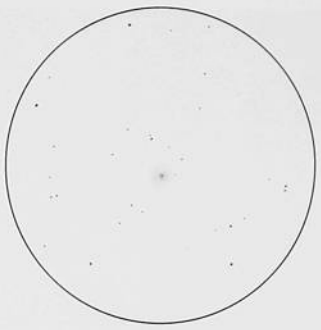
NGC	*Type*	α_{2000} h m	δ_{2000} ° ′	*Const.*	*Size* ′	*Mag.*	*Description*
6606	Gx	18 14.7	+43 16 *r*	Lyr		14p	vF, S, R, gbM, vF* inv
6612	Gx	18 16.2	+36 05 *r*	Lyr		15p	eeF, eS, R, v diffic
6640	Gx	18 28.1	+34 18 *r*	Lyr		14p	vF, S, R, vlbM
1288 I	Gx	18 29.4	+39 43 *u*	Lyr	1.3	14p	v F, S, lE, 3 st nr
6646	Gx	18 29.6	+39 52 *r*	Lyr		13p	F, S, iF
1289 I		18 29.8	+40 00 *d*	Lyr			eeF, pS, lE, 3 st nr
6657	Gx	18 33.0	+34 02 *r*	Lyr		14p	vF, vS, sbM
6663	Gx	18 33.5	+40 03 *r*	Lyr		15p	eeF, pS, R, v diffic
6672	Gx	18 33.8	+42 48 *r*	Lyr		15p	2 close st, n one nebs
6662	Gx	18 34.0	+32 03 *r*	Lyr		15p	F* in vF, vS, lE nebу
6665	Gx	18 34.5	+30 42 *r*	Lyr		14p	vF, vS
6666		18 35.3	+33 35 *D*	Lyr			eF, S, R, v diffic
6671	Gx	18 37.4	+26 24 *r*	Lyr		14p	vF, vS, R, mbM
6675	Gx	18 37.4	+40 04 *r*	Lyr		13p	vF, E, 45″
6685		18 39.9	+39 59 *D*	Lyr			eeF, vS, R, v diffic, sp of 2
4772 I	Gx	18 39.9	+40 00 *u*	Lyr	1.1	15p	eF, eS; 6685 f 2′, 2′.7 s
6686	Gx	18 40.1	+40 08 *r*	Lyr		15p	eeF, eS, R, v diffic, nf of 2
6688	Gx	18 40.7	+36 16 *r*	Lyr		14p	F, pS, R, bM
6693	*	18 41.6	+36 55 *r*	Lyr			vF
6692	Gx	18 41.7	+34 49 *r*	Lyr		14p	vF, vS, irrE, sev vF st inv
6695	Gx	18 42.7	+40 24 *r*	Lyr		14p	vF, S, irrE ns, vlbM
6700	Gx	18 46.0	+32 17 *r*	Lyr		14p	eF, lE, dif, iR
6702	Gx	18 47.0	+45 42 *s*	Lyr	2.1	12.2	pF, S, lE
6703	Gx	18 47.3	+45 33 *s*	Lyr	2.6	11.4	B, S, R, mbM
1294 I		18 49.9	+40 15 *d*	Lyr			eeF, S, iR, v diffic, F* close nf
6710	Gx	18 50.6	+26 50 *s*	Lyr	2.0	12.8	vF, S, R, bM
6713	Gx	18 50.7	+33 57 *r*	Lyr		14p	vF, S, R, bM
1296 I	Gx	18 53.3	+33 04 *u*	Lyr	1.3	15p	eF, pS, iR, 4′ np M57
6720	Pl	18 53.6	+33 02 *s*	Lyr	2.5	9.0	!!!, ◎, B, pL, cE (in Lyra); = M57
6731	–	18 57.0	+43 04 *r*	Lyr			vF
6740	Gx	19 00.8	+28 45 *r*	Lyr		15p	eeF, S
6743	?	19 01.4	+29 16 *A*	Lyr			Cl, pL, P, st 11...12
6745	Gx	19 01.6	+40 45 *r*	Lyr		13p	vF, lE ns
6766	–	19 09.9	+46 15 *r*	Lyr			○, stellar
6765	Pl	19 11.1	+30 33 *s*	Lyr	0.6		F, S, E
6767	–	19 11.6	+37 43 *r*	Lyr			vF, S, R, stellar, S* nr n
6779	Gb	19 16.6	+30 11 *s*	Lyr	7.1	8.3	⊕, B, L, iR, gvmCM, rrr, st 11...14; = M56
6791	OC	19 20.7	+37 51 *s*	Lyr	16	9.5	vF
6792	Gx	19 21.0	+43 08 *r*	Lyr		13p	F, E 26°, glbM, *9.5 nf

– 1 –

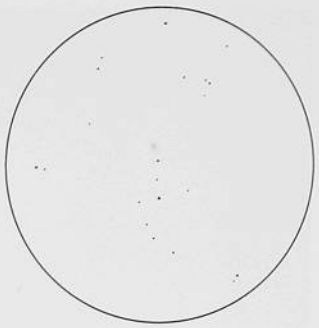
Galaxy NGC 6646. All sketches in this article are by Paul Brown using a 16-inch f/4.5 reflector. 180x.



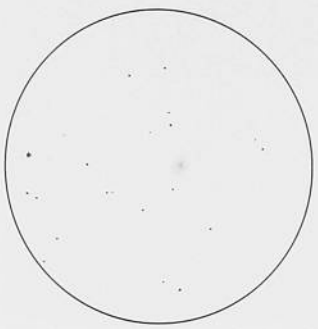
Galaxy NGC 6675, a direct vision object at 80x. The galaxy's diameter is about 1.3'. 127x.



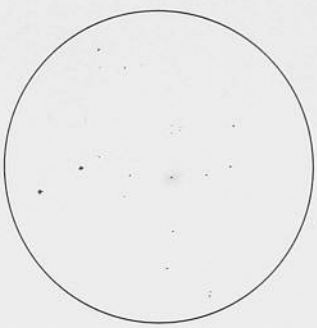
Perfectly round, galaxy NGC 6688 appears to have a stellar nucleus. 180x.



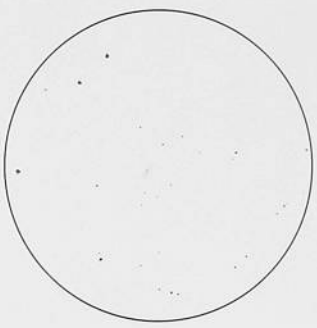
NGC 6692 is elongated roughly east-west and has a 15th-magnitude star on its eastern end. 127x.



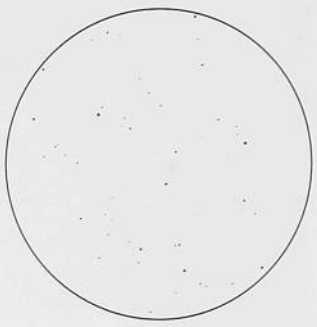
NGC 6702 is a small, bright galaxy visible with direct vision and is elongated southwest-northeast. 180x.



NGC 6703, Lyra's brightest galaxy, is visible directly and has an irregular halo surrounding a bright, condensed center. 180x.



UGC 11380 is an easy object for direct vision at 80x. A faint stellar nucleus appears in the galaxy's core. 180x.



UGC 11397 is flanked by 14th and 15th-magnitude stars and is visible as a pale patch of light. 180x.

surface brightness halo appeared about 40" across and roughly circular — it was a little too faint to get a good fix on any elongation. The relatively large core grew a little brighter across the center and seemed slightly mottled. In his 16-inch scope Paul saw it measuring 1.3' in diameter, slightly elongated southeast-northwest, and also saw "some hint of patchiness using averted vision." If you star-hop from Vega to NGC 6675, about halfway you'll pass the fine, red, 6th-magnitude variable star **XY Lyrae**.

About a degree and a half north of NGC 6675 is the double star **ADS 11500**. The nineteenth-century observer Thomas W. Webb called this star's components "minute but pretty" in his 3.7-inch refractor. I resolved them at just 30x in the 6-inch, so the equally bright pair should be easy in just about any instrument.

Not far away, of course, is **Epsilon[1,2] Lyrae**, catalogued as ADS 11635. The target of many viewing sessions, the famous "Double-Double" can be cleanly resolved in a 2.4-inch refractor of good quality. Epsilon[2] (the brighter, more southerly [CD] components) are easier to see because their magnitude difference is only 0.2, whereas the AB pair have a Δm of 1.1.

In the 6-inch scope the magnitude 12.5 to 13 EF components, known as Sh 277, were easily visible at 75x, lying between the bright double pair. The G component, also between the two pairs, glows dimly at about 14th magnitude and was visible with averted vision at 175x.

ADS 11504 is the bright star about 3° west of Beta Lyrae and serves as a good star-hopping checkpoint heading toward the galaxies UGC 11265, NGC 6640, and NGC 6657 in the southwest corner of the constellation. ADS 11504 is a wide but very unequal pair. I needed to use 75x with the 6-inch scope to pick it up.

Despite its rather faint catalogued magnitude, **UGC 11265** is a relatively easy galaxy because it is a compact object and has the highest surface brightness of any of the galaxies on our list. It is also easy to locate, lying on the north side of a parallelogram of 7th- and 9th-magnitude stars plotted on *Uranometria* and *Atlas Borealis* (the galaxy is not plotted on either atlas).

With the 6-inch, UGC 11265 appeared moderately faint and substellar at 75x. At 150x the galaxy's diameter was only about 15" and the light was well concentrated to a stellar center. Paul observed it as twice as large, though at first he needed 125x just to distinguish it from a star. The nearby galaxies **NGC 6640** and **NGC 6657** are slightly fainter than UGC 11265 and have much lower surface brightnesses.

Lying in a rich field of stars is **NGC 6671**. This galaxy sits between two stars at the southeast end of a 5'-long chain of five relatively bright stars. These stars are shown well in Paul's field sketch. In the 6-inch scope, NGC 6671 seemed to touch a 13th-magnitude star 28" away in position angle (p.a.) 65°. An 11th-magnitude star lies 40" away in p.a. 310°. The circular spot had a moderate, sharp concentration toward a stellar nucleus. Paul thought the galaxy measured 45" across and confirmed the stellar nucleus.

NGC 6688 also lies in a field with many stars. This object was conspicuous by its size in the 6-inch at 50x. At 150x the moderately low surface brightness glow spanned about 1' by 0'.8 and was elongated southeast-northwest with little central brightening. A magnitude 14.5 or 15 star was occasionally visible with averted vision about 1.1' south.

Two somewhat brighter stars lie off NGC 6688's southwest flank about 1.5' away. These may have influenced my comments about elongation. Alister and Paul agreed with the photographic impression that the galaxy is circular. In a 12.5-inch scope Alister saw NGC 6688 as slightly larger than 1' and uniformly bright except for a marginally visible stellar nucleus that appeared as bright as the star to the south.

Paul saw NGC 6688 as a mottled halo that sharply brightened within the 20" core to a stellar nucleus. He also noted a

condensation in the northwest side, which the *POSS* shows to be a close pair of magnitude 15 or 16 stars superimposed on the galaxy. The fainter, elongated galaxy **UGC 11325** lies 7.5' to the south.

Among the most difficult objects in Lyra is **NGC 6692**, which lies in the same medium-power field with the bright, wide pair **ADS 11593**. I called the galaxy "pretty faint" in the 6-inch scope. At high power the halo was about 30" in diameter with a moderate, smooth brightening across the center, showing no well-defined core or nucleus. On the other hand, Alister saw no central brightening at 250x in a 12.5-inch instrument.

Aperture comes through again, as Paul saw NGC 6692 as an object measuring 35" by 30", elongated in position angle 110°. (The latter agrees exactly with the angle given in the *UGC*.) Paul also espied a 15th-magnitude star within the southeast edge of the galaxy, which was confirmed on the *POSS*.

Now we come to the only close pair of galaxies in Lyra, **NGC 6702** and **NGC 6703**. NGC 6703 is a full magnitude brighter than its companion 12' to the northwest. NGC 6703 was easy at low power in the 6-inch scope. It is located along a conspicuous arc of stars including two magnitude 12.5 stars to the south and another north-northwest.

NGC 6703's circular glow was about 50" across (a little larger than the separation of the two stars to the south), rising to a bright core and an occasionally visible stellar nucleus. In a 12-inch Cassegrain scope, my friend Chris Luginbuhl saw NGC 6703 as a glow measuring 1.25' across (about the separation of the closer star south from the nucleus), brightening with a moderately strong concentration toward a prominent nucleus that appeared substellar at 225x.

Paul found NGC 6703's halo irregularly bordered and patchy: specifically, a dark patch northeast of the core and a brighter patch on the northwest flank appeared during moments of critically sharp atmosphere. The galaxy's stellar nucleus seemed offset to the southeast side of the 20" core. The *POSS* image of this galaxy is grossly overexposed, so confirming these details will require a large-scale, short-exposure photograph.

The faint companion, NGC 6702, seems difficult compared to its neighbor because of its small size. The 6-inch scope revealed a 30" by 20" oval elongated northeast-southwest. The galaxy's light was smoothly brighter across the center, showing no conspicuous core or nucleus. A 14th-magnitude star was visible 1.1' to the northeast. Chris saw NGC 6702 as an object measuring 50" by 30" in p.a. 70°. The overall brightening across the center was poor except in the inner regions. The 15" core seemed more strongly elongated than the halo. The faint star to the northeast marks the start of a string of stars that arc across the northern side of the galaxy.

The faintest of three planetaries we'll discuss is **Minkowski 1-64**, plotted on *Uranometria* chart 117 with the Perek-Kohoutek designation PK 64+15°1. After training my scope on this object, I found a small patch with a moderate surface brightness at 75x, neatly tucked in a group of 10th- to 12th-magnitude stars. At 150x the nebula seemed concentrated as though a star were involved, but it was too faint to tell clearly what was going on. An anonymous, 11th-magnitude pair lies in the field 6.5' to the southwest. This pair's separation, about 10" as measured on the *POSS*, is about the same as the observed diameter of the nebula.

Paul's telescope clearly revealed the nebula, along with a 15th-magnitude star superimposed on its northern edge. The two were "resolved" by going to 425x. Paul also suspected a brighter patch or patches on the western side of the nebula. The photograph in the Perek-Kohoutek catalogue shows a fine, miniature Ring Nebula.

NGC 6710 was another tough galaxy for the 6-inch scope, just visible at 75x and lying 1.6' northwest of an 11th-magnitude star. However, I first spotted this object at 150x only after a few moments' search. NGC 6710 appeared like a 20"-diameter patch of light, slightly elongated northeast-southwest with moderate broad concentration across the center. The galaxy's center showed a few starlike spots at the threshold of visibility. A very faint star about 1' southwest of NGC 6710, appearing to be magnitude 14.5 or 15 on the *POSS*, makes a triangle with the galaxy and the brighter star.

Like many of the sky's most familiar objects, it is hard to find thorough visual descriptions of the **Ring Nebula**, M57 (NGC 6720). People look at it so often they neglect to see anything! The Ring Nebula is visible as a tiny, pale spot in common, handheld binoculars. A simple 2.4-inch refractor reveals the oval annulus, elongated in position angle 65°, at low power even from big-city skies.

During my 6-inch observation last summer, very small variations in the brightness of the ring were evident: The acute ends appeared dimmer, the obtuse sides brighter, and the north-northwestern side brightest of all. The interior of the ring was filled in and conspicuously brighter than the sky outside the nebula. As you go to larger apertures, subtler variations in the brightness and width of the ring can be seen. For instance, the outer borders of the obtuse sides are slightly brighter than the rest. You may want to compare the visibility of these details with and without sky-suppressing nebula filters. However, all the details I just mentioned are visible from a dark site without filters.

The Ring's central star is usually a challenge for any telescope. Given sufficient aperture (about a 12-inch), the principal requirement for visibility is good seeing. Viewing the star comes down to a signal-to-noise problem: In poor seeing the

Deep-Sky Objects in Lyra

Name	RA (2000) Dec.	Type	Size	p.a.	B_T	SB	Remarks
NGC 6646	18h29.6m +39° 52'	Sa	1'.3x1'.3	70:°	12.6V	13.1V	type from *POSS*: SAa.
UGC 11265	18h31.6m +33° 56'	comp.	0.9'x0.9'	-	14.0	13.6	type from *POSS*: E0.
NGC 6671	18h37.4m +26° 25'	SA(r)b?	1.9'x1.9'	-	13.3	14.6	
NGC 6675	18h37.4m +40° 03'	Sbc	2.0'x1.5'	130°	13.2	14.3	type from *POSS*: SA(r:)b I.
NGC 6688	18h40.7m +36° 17'	SA0+	1.9'x1.9'	-	13.6	14.9	UGC 11325 (mag.z 14.6) 7'.5 SSE.
NGC 6692	18h41.7m +34° 51'	-	1.2'x0.8'	110:°	14.3:	14.1	type from *POSS*: E/S0.
NGC 6702	18h47.0m +45° 42'	E3:	2.1'x1.6'	65:°	12.2	13.6V	type from *POSS*: SA(r)0.
NGC 6703	18h47.3m +45° 33'	SA0-	2.6'x2.5'	-	11.3V	13.2V	
M1-64	18h50.0m +35° 15'	pn	18"x17"	-	13.3:v	-	PK64+15°1.
NGC 6710	18h50.6m +26° 50'	SA:0+	2.0'x1.2'	40:°	13.1V	13.9V	
NGC 6720	18h53.6m +33° 02'	pn	86"x62"	65:°	8.8v	-	PK63+13°1. Ring Nebula = Messier 57. Central star V=15.0.
δ Lyr	18h53.5m +36° 55'	III3p	20'	-	3.8	-	Stephenson 1.
UGC 11380	18h56.8m +36° 37'	Sab	1.7'x0.7'	172°	13.7	13.7	type from *POSS*: (R?)SB: (r:)ab.
NGC 6745	19h01.7m +40° 45'	pec	1.6'x0.7'	12°	13.3	-	uncorrected *UGC* dimen and *CGCG* mag.
UGC 11397	19h03.8m +33° 51'	SBa	1.3x0.8	95°	13.6	13.4	type from *POSS*: SB(r)b I.
NGC 6765	19h11.1m +30° 33'	pn	38"	-	12.9v	-	PK62+9°1.
NGC 6779	19h16.6m +30 11'	X	7'.1	-	8.3	-	Messier 56.
NGC 6791	19h20.7m +37° 51'	II3r	16'	-	8.2		-
NGC 6792	19h21.0m +43°08'	SBb	2.4x1.4	25°	12.9	14.1	type from *POSS*: SA(s)b I-II. UGC 11430 11'.8 NNE.

image is broadened and fades to merge with the bright background of the Ring's interior, even if the star is otherwise bright enough to detect. I have seen M57's central star clearly in Lowell Observatory's 42-inch telescope, but only because sheer aperture overcomes the signal-to-noise problem. In 12- or 16-inch telescopes, use your highest reasonable magnification to maximize contrast between the star and the nebulous background and remember the requirement for good seeing.

On the eastern side of the nebula, 64" from the center, is a V-magnitude 13.0 star that is visible in most telescopes at high power. I have always wanted to know the magnitude of this star, and in preparation for this article, I measured it using the Lowell 21-inch photometric telescope, deriving a measure of 13.0. In my 6-inch scope I could also glimpse a magnitude 14.5 star (visually estimated) 75" to the northwest.

The faint double star **GP 192** lies 3.6' west and slightly north of the Ring's center. This star is the first reasonably bright star west of the Ring. It was first noticed as double only in 1985 by Yugoslavian astronomer Georg Popovic using the 26-inch refractor at Belgrade. He estimated magnitudes of 11.0 and 11.5, but these are clearly wrong. I measured the combined brightness as V = 12.8, slightly brighter than the star immediately east of the nebula. The correct magnitudes are noted in the table. I could barely detect the stars using 300x with the 6-inch scope. Only 1.2' north of the pair is the faint galaxy **IC 1296**, visible as a low surface brightness object in 16-inch and larger telescopes.

Between the Ring and Gamma Lyrae to the east is the pair **ADS 11871**. This star is an interesting, unequal double for 6-inch telescopes, but requires high power for a clear view. On two occasions I used the Lowell 24-inch Clark refractor stopped-down to 6-inches aperture to resolve this star at around 400x. The relatively faint secondary lay close to the first bright diffraction ring and was sometimes distorted as the seeing changed. The separation will be closing in coming years, making it an even tougher object than it currently is.

The field surrounding **Delta[1,2] Lyrae** contains a bright but sparse open cluster, first studied by C. Bruce Stephenson at Case Western University's Warner & Swasey Observatory in Ohio. My 6-inch scope revealed an unconcentrated group of about fifty stars in a 30' area including orangish Delta[2] (the brighter star) and bluish Delta[1] Lyrae, both of which are members of the cluster. Between these two stars is a 9th-magnitude star with two faint companions — a 12th-magnitude star 26" to the southwest and a 13th-magnitude star 23" to the northeast. Less than a degree north is **ADS 11811**, a close pair with a distant, faint companion. The star was resolved at 175x in the 6-inch scope.

Southeast of the Delta Lyrae cluster is the faint galaxy **UGC 11380**. This object was a challenge to find in the 6-inch scope, lying 10' northwest of a 7th-magnitude star. At first I was confused by a clump of three 13th-magnitude stars 9' west-northwest of the star that appeared nebulous at 75x. At higher powers the clump was resolved, then identification of the galaxy was obvious.

UGC 11380's 1' by 0.25' halo was elongated north-south with a bright, circular 15" core. Two magnitude 12 or 13 stars were visible to the galaxy's southern side. In his 16-inch scope Paul saw it measuring 1.5' by 0.5' in p.a. 180°, not far off the *UGC* value of 172°. A stellar nucleus was visible in a core offset toward the west flank of the halo. The eastern side of the halo faded more gradually than the opposite edge. Paul's sketch shows many wide pairs in the field around the galaxy.

NGC 6745 is an unusual galaxy showing some details in large instruments. The galaxy's moderately faint glow was visible with some effort at 75x in my 6-inch scope. The oval halo measured about 1' by 0.6' in p.a. 10°. The light was moderately concentrated to a patchy, somewhat brighter core. A triangle of magnitude 12 to 13 stars (45" on-a-side) lies about 2' north of NGC 6745, and a faint pair is about 5' to the southeast.

Alister saw NGC 6745 as a small blob elongated in a 3-to-1 ratio. The western edge of the halo was straight and sharply defined, while the diffuse east flank was rounded and brighter. He glimpsed a very faint star or knot along the southwestern flank. Paul noted that the north end is irregular and less distinctly bounded than the galaxy's southern tip. As in smaller apertures, the major axis shows a string of faint, starlike spots at the threshold of visibility.

On the *POSS*, NGC 6745 has an unusual appearance, looking like a much-distorted spiral covered with emission nebulosity. Observers with larger telescopes might try to see if this nebulosity can be brought out by a UHC or other sky-suppressing filter.

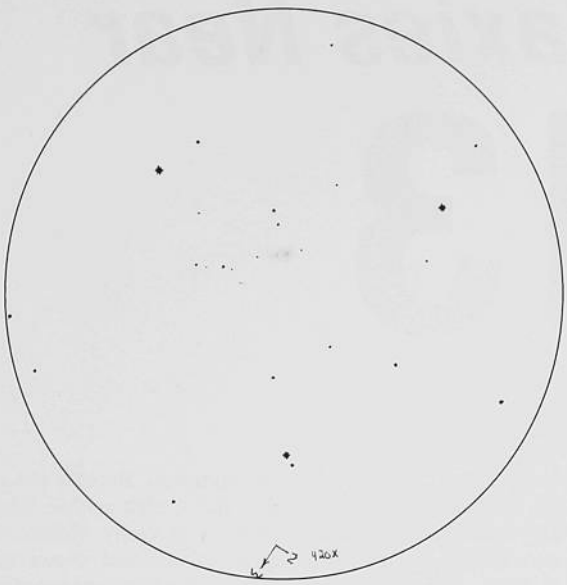
Another attractive, unequal pair is **17 Lyrae** (ADS 12061). I really needed 300x for a clear shot at this in the 6-inch scope. The pair is the brightest of an apparent cluster of about fifteen stars of magnitudes 9 to 12 in a 10' area mostly north of 17 Lyrae. The large proper motion of 17 Lyrae excludes the possibility of the cluster's existence.

From 17 Lyrae it is a short star-hop to **UGC 11397**, the only galaxy on the list I failed to find. Its appearance on the *POSS* suggests Zwicky's magnitude of 14.0 is too bright, perhaps by as much as a full magnitude. Paul had no trouble with it in the 16-inch scope, however, reporting that UGC 11397 lies in a beautiful, starry field (at only 12° galactic latitude) between two interfering stars. The galaxy's 40" by 25" halo was elongated east-southeast to west-northwest, brightening to a similarly elongated core. A 15th-magnitude star was visible 30" due south of the galaxy's center along with a 14th-magnitude star 33" away in p.a. 325°.

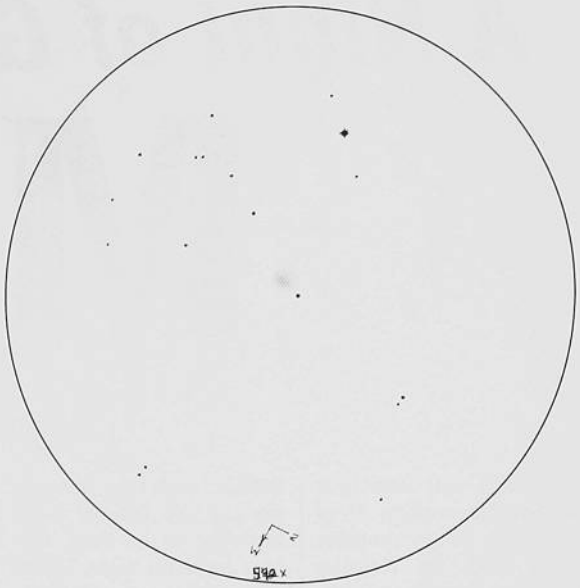
Double Stars in Lyra

Name	R.A. (2000) Dec.	Mags.	Sep.	p.a.	Year	Spectral type
ADS 11500	18h36.2m +41°17'	7.7, 7.7	5.1"	340°	1969	A1V+A0V
ADS 11504	18h36.6m +33°28'	5.5, 10.7	7.3"	205°	1958	B8II-IIIHgMn
ADS 11635AB	18h44.3m +39°40'	5.0, 6.1	2.5"	354°	1985	A3III+A8III-IV
ADS 11635CD	18h44.4m +39°40'	5.2, 5.5	2.4"	89°	1985	A8Vn+F0Vn
ADS 11811AB	18h54.0m +37°23'	8.2, 8.7	1.5"	156°	1980	G2IV
AC		8.2, 11.1	20.7"	143°	1925	
GP 192	18h53.3m +33°02'	13.3,13.8	2.9"	34°	1985	
ADS 11871	18h57.0m +32°54'	5.4, 7.5	1.2"	31°	1986	F9.5V+K1V
ADS 12061	19h07.4m +32°30'	5.3, 9.4	3.5"	301°	1963	F0V
ADS 12090AB	19h08.7m +37°55'	8.8, 10.5	20.6"	338°	1964	
AC		8.6, 9.2	75.2"	348°	1964	
AE		8.6, 12.9	52.0"	331°	1964	
CD		9.9, 10.1	6.3"	293°	1967	
ADS 12093	19h08.8m +34°46'	7.0, 9.0	13.7"	269°	1958	B5V+A2
ADS 12101	19h09.1m +34°36'	6.7, 8.1	16.2"	262°	1974	G1V+G5
ADS 12239AB	19h15.9m +27°27'	7.2, 7.3	0.9"	158°	1985	B5III
AC		7.2, 8.6	47.5"	268°	1959	

Notes on both tables: Double star data comes from the collection of sources discussed in the double star column on page 38. Integrated B magnitudes are given for galaxies, unless marked with a V. As a rough guide, the V magnitudes are typically about one magnitude brighter than those on the B system. Galaxy types from the POSS *were determined by B. Skiff. Magnitudes for planetaries were provided by Jack Marling.*



NGC 6765 is a faint planetary framed by two svery faint stars. 420x + O III filter.



PK 64+15.1 is a faint planetary that appears like an out-of-focus star. 542x + O III filter.

About 2° east-northeast is **ADS 12093**, the northwesternmost of two wide, bright pairs in the same field notable for their similarity. Both are good targets for small telescopes and low powers. ADS 12093 has a bluish primary, and nearby **ADS 12101** has a yellowish primary. Though ADS 12093 is probably an optical pair, ADS 12101 is almost certainly a binary, composed of two sunlike stars with an orbital period of many centuries.

Our third planetary, **NGC 6765**, lies in a still richer field. I found the 13th-magnitude nebula at 75x without filters in the 6-inch scope. UHC and O III filters helped somewhat in spotting it, but the O III did not provide a dramatic improvement. The rectangular-oval nebula was about 20" by 12" in size, elongated in p.a. 30°, and pointed toward two magnitude 10.5 or 11 stars 2' to the south. NGC 6765 brightened somewhat across the center, where some sort of condensation was visible. A magnitude 14.5 star lies off the nebula's northern edge, 33" from the center.

Paul saw many interior details in NGC 6765 by using 425x. He noted a distinct circular knot on the northern side and another smaller knot on the southern side. The latter proves to be a faint pair of stars on the *POSS*. A 15th-magnitude star near the nebula's southern tip, together with a magnitude 14.5 star on the northern tip, framed the nebula. They are 1.0' apart, providing a good gauge of the observed size of the nebula (Paul saw it as about 45" by 25").

The globular cluster **M56** (NGC 6779) lies only a few fields east of NGC 6765. I found M56 moderately faint, though small, in a 3-inch finder scope at 20x. A 9th-magnitude star was conspicuous on the cluster's western side. In the 6-inch scope M56 was partially resolved with much haziness at medium-to-high powers. I counted about forty stars within the radius of the bright star, which lies 2.6' from the center.

Overall, the cluster's light showed a moderate, broad increase in brightness across the center. The core was about 1.7' across. The cluster's outlying members clearly spill beyond the radius of the bright star before merging with the rich background, implying a total diameter greater than 5'. Photometric studies show the brightest stars in the cluster glow at V magnitude 13.0, so any telescope reaching at least this faint will resolve some members of the cluster.

Our second open cluster, **NGC 6791**, is faint but very rich in stars. It is famous among galactic astronomers for being among the oldest open clusters known in the Galaxy, at least several billion years old. NGC 6791 is a notorious object for amateurs; its low surface brightness makes the cluster difficult if skies are at all bright. From a dark site it was easy to see in a 3-inch finder scope, appearing about as bright but a little smaller than NGC 188, a similar cluster near the north celestial pole.

In the 6-inch scope at 30x, NGC 6791 was a conspicuous fuzz in a 1.6° field with what appeared to be many field stars superimposed on the cluster. The brightest of these is a magnitude 10.5 star on the northwestern side. At 150x the granular glow was 8' to 10' in diameter, slightly elongated roughly east-west, and showed a weak, broad concentration. The superimposed field stars are concentrated mostly on the northeastern side of the cluster.

A few degrees west of this cluster is **ADS 12090**, an interesting multiple star including a nice, faint pair. The stars are arranged in an arc starting with a bright, wide pair, leading northwest to a 13th-magnitude star, and finally ending with the closer, 10th-magnitude CD pair. All five stars were clearly resolved in the 6-inch scope.

Approaching the border of Cygnus, we come to **NGC 6792**, one of the brightest galaxies in Lyra. It was moderately faint in the 6-inch scope, lying 1.5' southeast of a 10th-magnitude star. At 150x the 1.5' by 0.6' halo was elongated in p.a. 20°, showing tapered tips with averted vision. The central brightening was moderate and broad, so no well-defined core or nucleus was evident. A pair of magnitude 12 or 13 stars separated by 15" lies 3.5' to the southwest. In a 12.5-inch scope, Alister saw a stellar nucleus and a magnitude 15 or 16 star just off the northeastern end, 1.4' from the center. The pair to the southwest has a third star involved, making a tight triangle.

Isolated in the southwest corner of Lyra near the Cygnus Milky Way is **ADS 12239**, which I offer as a challenge. The stars in this 7th-magnitude pair are currently separated by just the diameter of the Airy disk of a 6-inch telescope. When I observed them on a cirrusy night at Kitt Peak last summer, they were recognizable at 175x but required 300x for a clean split. The Airy disks were just separated in the best seeing. I estimated a Δm of 0.3 magnitude, definitely not as small as 0.1, as the *WDS* indicates. The widely separated third star was easy to see at any power.

This project was a challenge to put into writing and would not be as complete without the major observational contributions of Paul Brown. I am grateful to Harold Corwin for providing up-to-the-minute data from the *RC3* prior to publication.

Brian Skiff is coauthor of the Catalogue and Handbook of Deep-Sky Objects, *recently published by Cambridge University Press.*

A Night of Galaxies Near M13

by Robert Bunge

My smarts tell me that because you're reading *Deep Sky* magazine, you've probably stared at M13, the Hercules Cluster, a few times in your life. If you own a large telescope or have access to one, chances are you've seen the little galaxy just northwest of M13, designated NGC 6207. This distant spiral makes a fascinating aside to watching the big ball of stars because it is many times more distant.

However, chances are you haven't seen the really tough objects lying near M13. A close-up examination of the Palomar Observatory *Sky Survey* (*POSS*) plate containing M13 reveals a wealth of faint galaxies scattered within a 4° radius of the great cluster. While some of these galaxies are NGC and IC objects, most of the galaxies are "anonymous," which means they are not listed in the familiar, basic sources of deep-sky data. However, each of these remote galaxies is listed in one or more of three monster galaxy catalogs.

Invaluable sourcebooks for deep-sky researchers, the *Uppsala General Catalogue of Galaxies* (*UGC*), the *Morphological Catalogue of Galaxies* (*MCG*) and the *Catalogue of Galaxies and Clusters of Galaxies* (*CGCG*) together provide information on about 72,000 galaxies. The objects range from the brightest galaxies in the sky all the way down to objects with photographic magnitudes of 15.7.

One day I decided to investigate these faint galaxies near M13. Using the *POSS* plate as a guide, I plotted the galaxies on chart 114 of *Uranometria 2000.0*, with the thought of pushing my favorite deep-sky telescope to its limit. On the next favorable night, I took the chart out to the 31-inch f/7 reflector at Warren Rupp Observatory near Mansfield, Ohio. Each summer I spend great amounts of time showing M13 to visitors — nearly 4,000 people peeked at it in 1988 — and now I wanted to find something a little less mundane that I could show them along with the great cluster.

In the 31-inch scope at 170x, the M13 field appears covered with stars that blanket the view edge-to-edge. The cluster is resolved to the very center of its core. It's easy to follow lines of stars and see dark lanes and voids that seem to hover in front of the cluster.

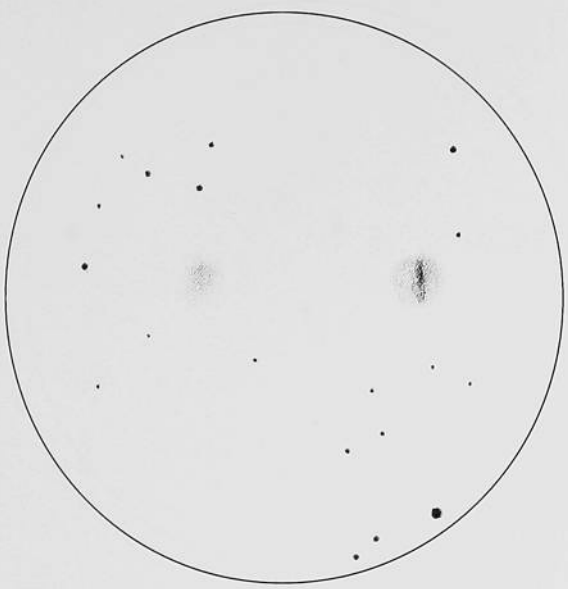
After enjoying the view of M13, I slowly turned the telescope to **NGC 6207**, located two-and-a-half fields of view to the northwest. Because this galaxy has a high surface brightness, it is easily visible with direct vision and shows mottling across its cigar-shaped surface. Because it is so easy to see, I have often shown NGC 6207 on public nights, if visitors seem to be interested in seeing a galaxy.

The Hercules Cluster, M13, is one of the most watched deep-sky objects in the summer sky. Yet several galaxies unknown to most observers lie nearby the great cluster. Photo by Martin C. Germano (6-inch f/8 refractor, hypered Tech Pan film, 30-minute exposure).

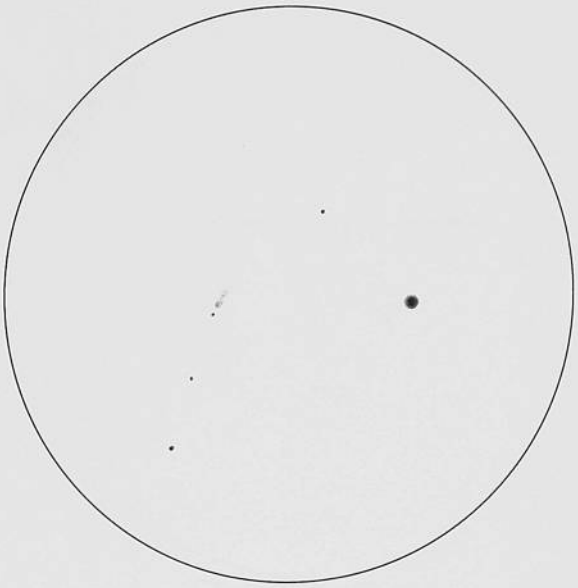
But a surprise lies halfway between the great cluster and its little companion. Although it is catalogued as an Sb-type galaxy with a magnitude of 12.9, **IC 4617** is not plotted on *Uranometria*. Although this tiny galaxy is relatively bright, it is an unusual challenge, even with a 31-inch telescope. IC 4617 appears to lie sandwiched between two stars that belong to a small parallelogram of stars. In the 31-inch scope I nearly always need averted vision to see IC 4617's tiny, fuzzy, featureless oval. If IC 4617 eludes you, not to worry. Other galaxies near M13 are far easier targets for small backyard telescopes. This is evidenced, in fact, by glancing at the *Uranometria* chart.

About 50' southeast of M13, *Uranometria* shows a small group of galaxies including **NGC 6194**, **NGC 6196**, **NGC 6197**, **NGC 6199**, and **IC 4614**. Unfortunately, a positional error in the *Revised New General Catalogue* caused these galaxies to be mislabeled on *Uranometria*. When I aimed the 31-inch scope toward the area shown on *Uranometria*, I observed three galaxies aligned north-south in a neat line. After making a drawing, I wandered off to other nearby objects.

Later I discovered Steve Gottlieb's letter in *Deep Sky* #5 (Winter 1983), and I read that



Galaxies UGC 10567 and UGC 10568 lie due east of M13. All sketches in this article are by Robert Bunge using the 31-inch telescope (at 200x) at Warren Rupp Observatory.



Sixteenth-magnitude galaxy Zwicky 197.016 lies in the same field as the bright star SAO 65578.

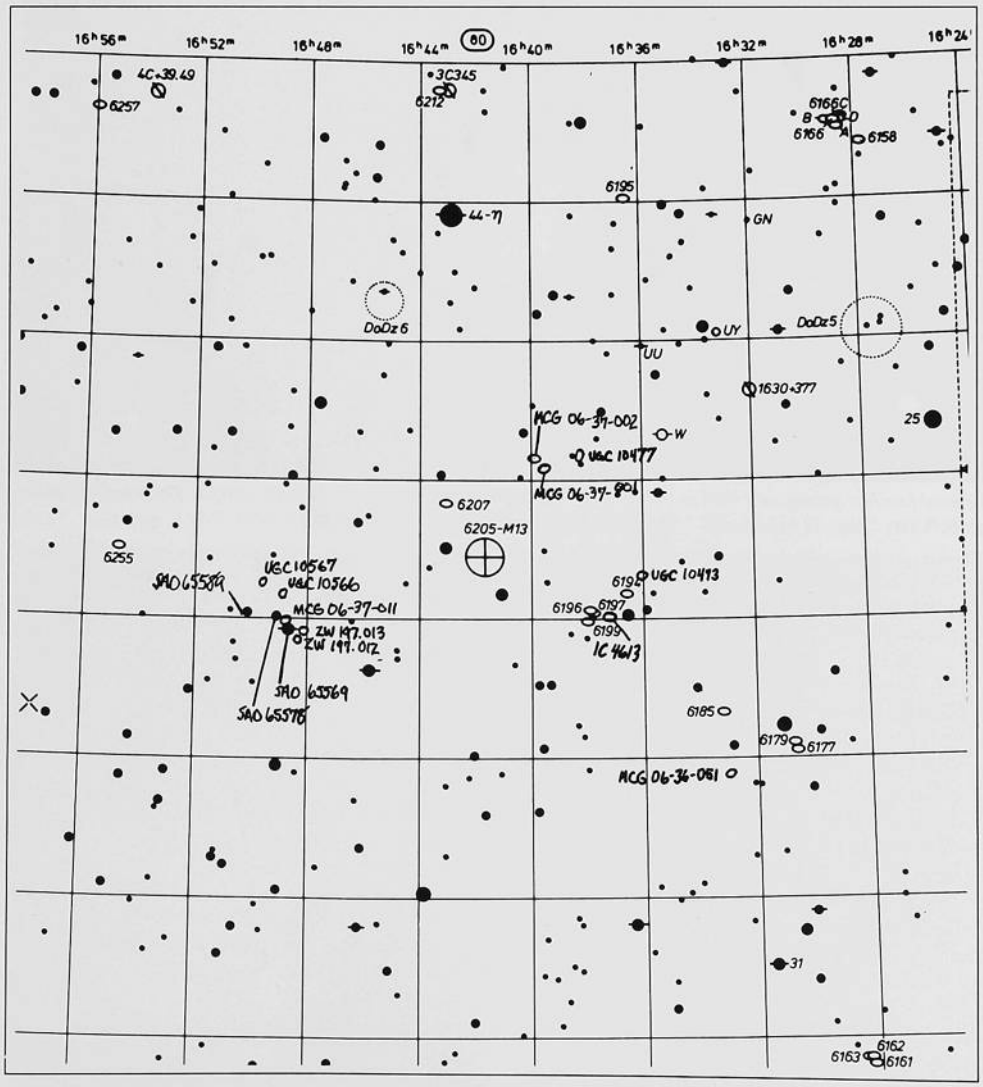
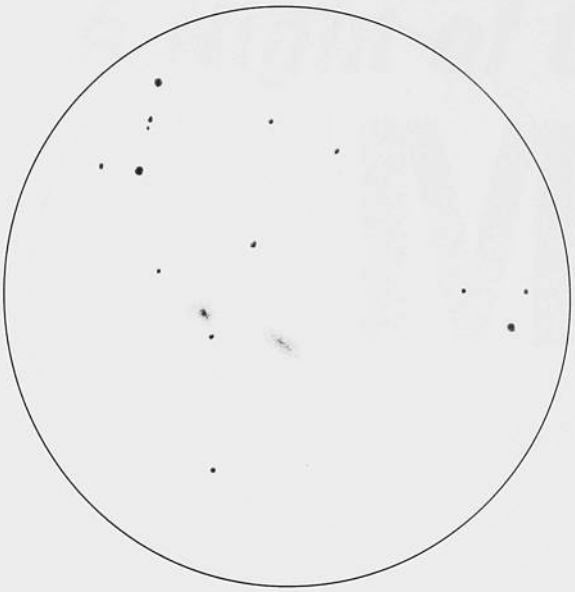


Chart 114 from Uranometria 2000.0, *volume 1, shows the area of the Hercules Cluster. In addition to the bright galaxy NGC 6207, thirteen other galaxy fields lie nearby. Copyright © 1987 Willmann-Bell, Inc.*

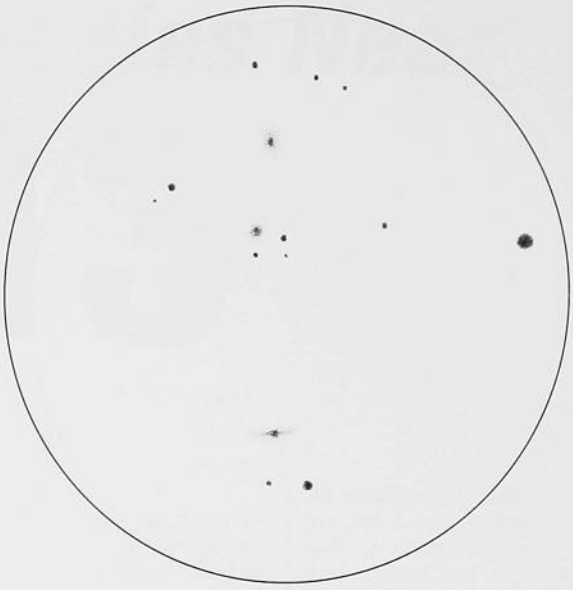
the line of three galaxies is formed by NGC 6197, NGC 6196, and IC 4614. The center galaxy, NGC 6197, is the brightest. In the 31-inch scope it was easy to see NGC 6197 as a tiny, 13th-magnitude glow. NGC 6196, a smaller, fainter blob, lies 3' south of NGC 6197. NGC 6196 showed a bright nucleus with an elongated disk around it, appearing about 14th magnitude overall.

Three arcminutes north of NGC 6197 is IC 4614. At 200x, this galaxy appeared to have a bright center core with a 2" halo surrounding it. It was noticeably fainter than NGC 6197. In his letter, Gottlieb described how Harold Corwin of the University of Texas at Austin had discovered that NGC 6199 is not a galaxy at all but a 14th-magnitude star. Sixteen arcminutes west-northwest of the line of galaxies is NGC 6194. I logged this object as an easy 13th-magnitude patch of light showing some mottling at 200x.

On the northwest side of M13 lies a galaxy that is plotted but unidentified on *Uranometria*. The first time I centered the big reflector on this area, I couldn't help noticing two galaxies in the field. On close inspection, it dawned on me that a fair amount of homework would be required to identify them. So I resorted to the monster catalogs and the



Dimly glowing at magnitudes 14.5 and 15.0, galaxies MCG+06-37-001 and MCG+06-37-002 form a pair even in a high-power eyepiece.

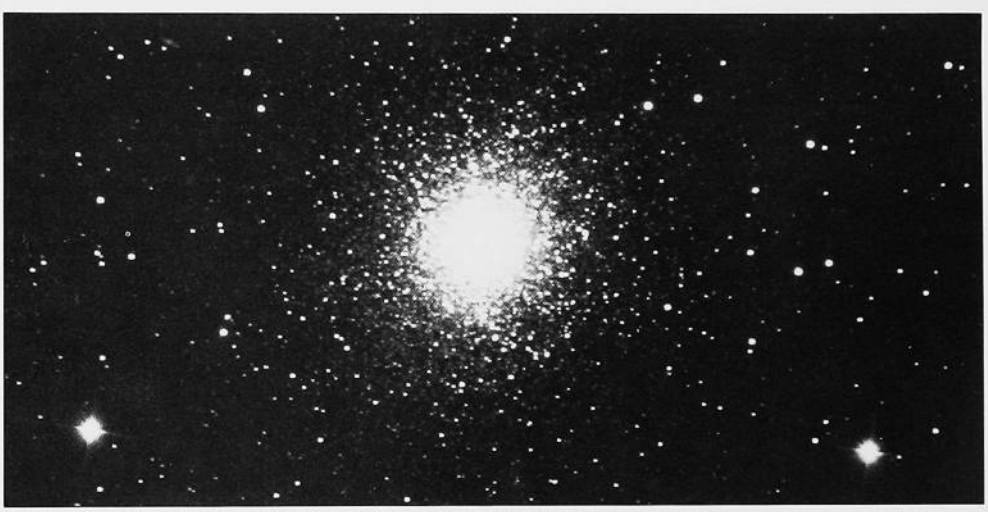


The NGC 6196 galaxy group lies 1° southwest of M13, and contains three galaxies brighter than 15th magnitude.

POSS. The plotted galaxy appears to be **MCG +06-37-002**. Listed at magnitude 14.5, this object appeared round with a stellar core. A 15th-magnitude star lay a few arcseconds south of the core, just outside of the edge of MCG +06-37-002's 3"-diameter glow. Twelve arcseconds east and a few arcseconds south of this galaxy I found the magnitude 15.2 galaxy **MCG +06-37-001**. This galaxy was substantially more difficult to see than MCG +06-37-002, but did offer a 5" elongation that I clearly observed at 200x. Under superb seeing, I would guess that telescopes much smaller than the 31-inch should show this feature.

Up to this point, I had observed the galaxies using only *Uranometria*. During a check for really faint galaxies, I noticed the entire area surrounding M13 was studded with anonymous galaxies. In fact I checked the *POSS* plate with a magnifying glass and noticed many unplotted galaxies just within reach of the plates. Some of these tiny galaxies — far beyond visual reach — appeared to be lodged within the boundaries of M13 itself.

A few nights after viewing the *POSS* plate I arrived at the observatory with Columbus telescope maker Bill Burton. We were both keen on making a systematic search for anony-

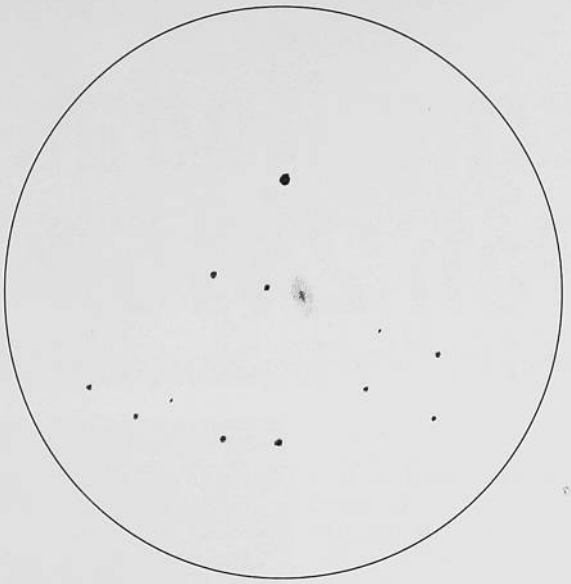


The most familiar galaxy near M13 is the bright Sb-type spiral NGC 6207, visible in the same low-power field as the great cluster. Photo by Al Lilge (12.5-inch f/8 Pro-Scope, 098 film, 120-minute exposure).

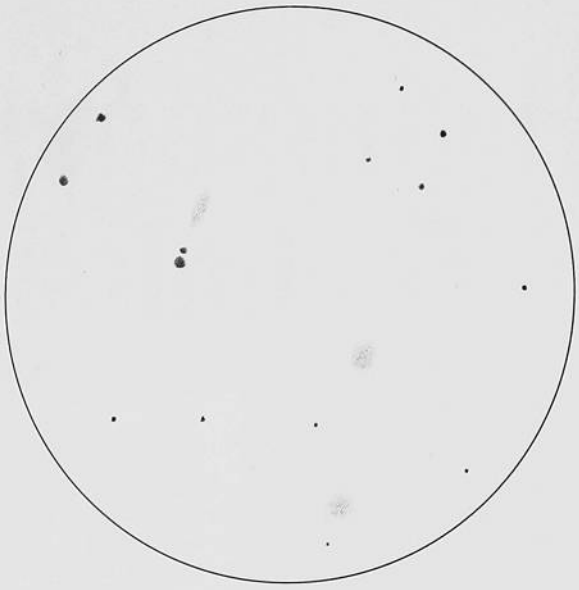
Faint Galaxies near M13

Galaxy	R.A.(2000.0)	Dec.	Mag.	Type	Notes
UGC 10477	16h37.4m	+37°16'	15.4	Sb	Not found
MCG+06-37-001	16h39.8m	+37°10'	15.0		
MCG+06-37-002	16h40.1m	+37°11"	14.5		
IC 4617	16h42.1m	+36°41'		Sb	
UGC 10544	16h46.7m	+36°05'	15.4	Sa	=Zwicky 197.009
Zwicky 197.012	16h48.3m	+35°50'	15.3		
Zwicky 197.013	16h48.3m	+35°54'	15.3		
MCG+06-37-011	16h48.7m	+35°55'	15.5		=Zwicky 197.014
UGC 10566	16h48.9m	+36°11'	15.3	S	=MCG+06-37-012
UGC 10567	16h49.1m	+36°13'	15.2		=MCG+06-37-013
Zwicky 197.016	16h49.4m	+36°03'	15.7		

Notes: The *UGC* gives sizes for UGC 10544 (1.0" by 0.5"), UGC 10566 (2.0" by 0.4"), and UGC 10567 (1.1" by 0.6"). The double star near MCG+06-37-011 is SAO 65569 (V=7.3). The next bright star east (near Zwicky 197.016) is SAO 65578 (V=8.4). The next star to the east is SAO 65589 (V=8.0).



UGC 10544 is a 15th-magnitude Sa-type spiral with a bright, starlike nucleus.



A complex and interesting field southeast of M13 contains two Zwicky galaxies and MCG+06-37-011, which lies adjacent to the double star SAO 65569.

mous galaxies in the region. No other use was scheduled for the 31-inch scope that night. M13 was placed high in the western sky. After looking at M13, I hopped over to the two MCG galaxies. Then, using the scope's 5-inch finder, I moved over to the position of **UGC 10447**, a faint, edge-on galaxy located between two bright stars.

I knew that I had the right field because the two stars were on opposite ends of the field of view at 200x. However, neither Bill nor I could see the galaxy, even at extremely high magnifications. The *POSS* shows UGC 10447, and the *UGC* lists its magnitude as 15.4. Our only suspected reason for not seeing the galaxy was overpowering glare from the two bright stars.

With that disappointing start, I moved the telescope back to M13 and continued to the position of **UGC 10544**, a little over 1° to the east-southeast. This galaxy was plainly visible with averted vision. It had a well-defined core surrounded by a milky, oval glow. I estimated its size at about 3" by 2". UGC 10544 must have a fairly high surface brightness, because we saw it rather easily and the *UGC* lists it at magnitude 15.4. Incidentally, many so-called anonymous galaxies are listed in more than one of the monster catalogs. UGC 10544 is also known as MCG +06-37-009.

About 3' east and a few arcminutes south of UGC 10544 lies a triangle consisting of two 8th-magnitude stars and a 7th-magnitude star shown as a double on *Uranometria*. Inspection of the *POSS* plate revealed a wealth of faint galaxies surrounding these stars. So with a fair degree of anticipation, I pointed the scope at the double.

I had a 28mm Pretoria eyepiece attached to the scope, yielding 200x. Peering into the eyepiece, I saw the star was indeed double, with the secondary lying to the northwest. Two galaxies were immediately apparent in the field. After carefully scanning the field, Bill pointed out a third galaxy close to the secondary. This object was significantly dimmer than the other two.

Later we identified this galaxy as **MCG +06-37-011**. This galaxy appeared to be about 16th magnitude — not an easy find even for the 31-inch scope. MCG +06-37-011 appeared spread out with an extension on its northwestern side. The galaxy did not appear to have a central brightening.

Some 24" west and 1" south of MCG +06-37-011 is the more impressive **Zwicky 197.013**, the best of the three galaxies surrounding the double star. Glowing at magnitude 15.3, this object clearly had a higher surface brightness than MCG +06-37-011. Indeed, Zwicky 197.013 was round and considerably smaller than the MCG galaxy. Located just 4" east of Zwicky 137.013 was **Zwicky 137.012**. This galaxy appeared larger and dimmer than its close neighbor.

Bumping the scope a field diameter to the northeast brought one of the 8th-magnitude stars, SAO 65578, into the field along with **Zwicky 197.016**, a magnitude 15.7 galaxy located northeast of the star. This galaxy at first appeared double because of a faint star of about the same brightness lying adjacent to the galaxy's center.

However, Zwicky 197.016 is an edge-on galaxy with a foreground star. After studying the galaxy carefully with averted vision, I could detect an elongation oriented north-south. Zwicky 197.016 appeared to be slightly larger toward the star. Just to be sure, I checked the *POSS* plate again and found a star in the observed position. I hadn't discovered a distant supernova.

The night had progressed more quickly than we would have liked. The once-high M13 was now sinking into the glow of Mansfield. I moved the scope north-northwest to the position of **UGC 10566**. This magnitude 15.3 galaxy was easily visible in the 31-inch scope. Averted vision showed a distinct brightening along a north-south orientation. The *POSS* shows clearly that this galaxy is a barred spiral.

Just 12" east and 2" north of UGC 10566 is **UGC 10567**. As I peered into the eyepiece and complained that this was the toughest galaxy of the night, Bill asked me to look up. Not only was M13 now down into light pollution, but the telescope was partially blocked by the dome slit. Nonetheless, I saw UGC 10567 as a faint, featureless spot, but I suspect it is much more impressive under better conditions.

After a couple of hours of searching, Bill and I had found nine so-called anonymous galaxies near M13. None of the objects was brighter than magnitude 14.5. Although we were using a large telescope, we are confident that most of these objects are visible in much smaller instruments. This should especially be true for observers at better sites than ours. This summer, as M13 shines against the black velvet of the night sky, spend an hour or two exploring the secret wonders scattered quietly about the great ball of stars.

Robert Bunge is an active deep-sky observer who lives in Columbus, Ohio. His last article was "Tracking Down the NGC 4005 Galaxy Group" in the Spring 1989 issue.

Hypersensitizing Kodak Technical Pan 2415

by Kim Zussman

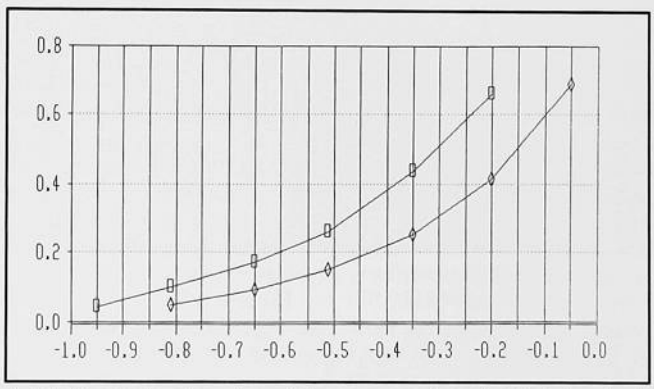
Hypersensitized Tech Pan 2415 is the film of choice for backyard astrophotographers. No other film can match its fine-grain definition, contrast, and low reciprocity failure. If you've carefully scanned the captions and credits in *Deep Sky* and ASTRONOMY over recent months, you've undoubtedly noticed the majority of published deep-sky images are Tech Pan photos. When hypered, this film simply can't be beat.

An ability to record extremely faint objects is one of Tech Pan's strongest points. Whether or not a film can record light only slightly brighter than the sky background is related to the film's signal-to-noise ratio. Fine-grain, high-contrast films like Tech Pan have the highest signal-to-noise ratios. This is especially true when they're exposed for long periods at dark-sky locations. Like most films, however, Tech Pan loses sensitivity when exposed to low-intensity light, an effect formally called low-intensity reciprocity failure.

Reciprocity failure can be minimized by proper hypersensitization. A great deal has been written about hypering Tech Pan film, and other methods of varying Tech Pan's speed and contrast are discussed at length in Kodak literature. Studying this information led me to investigate means of increasing the speed of Tech Pan by varying hypersensitization and developing techniques.

Hypersensitizing Tech Pan Film

The astronomical literature contains reports on various hypersensitization methods for Tech Pan (see the accompanying bibliography). Common methods include baking the film in pure hydrogen or a mixture of hydrogen and nitrogen called forming gas. The recipe for times, temperatures, and pressures varies considerably depending on the source. Edgar Everhart uses 92 percent nitrogen and 8 percent hydrogen (8 percent forming gas) over a range of temperatures to achieve an eightfold increase in speed for Tech Pan sheet film. William Liller uses 2 percent forming gas to increase the speed of Tech Pan sheet film over 12 times.



A plot of image density vs. log relative exposure shows that Tech Pan developed for 10 minutes in D19 (diamonds) yields greater density over shorter exposure times than Tech Pan developed for 5 minutes in D19.

Generally, astronomers do not use pure hydrogen because it is dangerous to work with. Although using pure hydrogen to hyper film results in greater speed, the gas is flammable and shouldn't be handled by anyone who is not trained to work with such substances. Eight-percent forming gas is the standard because it results in a good speed increase and is nonflammable.

The procedure for hypering film is relatively straightforward. The film is placed in a cassette and spooled on to a metal film reel, which is placed in a hypersensitizing tank. The film is then exposed to the mixture of gases in a vacuum environment so that harmful oxygen and water, which reduce the effectiveness of hypering, are drawn away from the film.

Besides the gas mixture, temperature is the most important factor controlling the film's sensitivity — higher temperatures mean shorter baking times. On the average, a hypering tank at 47° C with 8 percent forming gas at 15 psi above atmosphere results in a baking time of three days for Tech Pan. For optimum results, of course, each astrophotographer must tailor the temperature, pressure, and gas mixture used to his or her own routine.

How long should Tech Pan be hypersensitized? Experiments conducted by William Liller and Alex G. Smith — Liller using forming gas and Smith using hydrogen — showed that film speed increases rapidly with baking time, reaches a maximum, and then gradually decreases with further hypersensitization. So it is possible to "over-hyper" Tech Pan film.

The most common method used for gauging the degree of hypersensitizing that should be used is measuring "hyper-fog" density. This is a darkening of unexposed hypersensitized film visible after development. Hyper-fog can be estimated using a visual density stepwedge, which consists of a series of calibrated density filters mounted on a strip of acetate. A more accurate method of gauging hyper-fog is to use a densitometer.

Professional studies by Everhart, Liller, and Smith indicate that Tech Pan reaches maximum speed if hypersensitized to a fog density of 0.2 to 0.4 when developing in D-19 at 68° F for 5 minutes. Using a densitometer of my own construction, I have found that Tech Pan baked at 47° C in a single volume of 8 percent forming gas at 15 psi above atmosphere requires three days to reach a fog level of 0.3 to 0.4 when developed for 5 minutes. This simple method of fog density measurement can be used to select optimum baking times for any chamber temperature.

Increased Speed with Extended Development

Craig B. Conrad, Alex G. Smith, and William B. McCuiston evaluated nine developers for Tech Pan in a research project published in 1985. They concluded that D-19 gave the best combination of high speed and low fog. An interesting observation noted in their tests was that Tech Pan had a significantly higher speed when developed longer than the usual 5 minutes.

A 120-minute exposure on hypersensitized Tech Pan film records the spiral arms of galaxy M33 in Triangulum. This negative shows the brightest stars in the galaxy's arms resolved. All photographs in this article are by Kim Zussman and were made with a modified 11-inch f/10 SCT and hypered Tech Pan film.

Clockwise, from above: A 120-minute exposure reveals the edge-on galaxy NGC 5907 in Draco and its razor-thin equatorial dust lane.

The faint, outer arms of galaxy M77 in Cetus show in a 105-minute exposure.

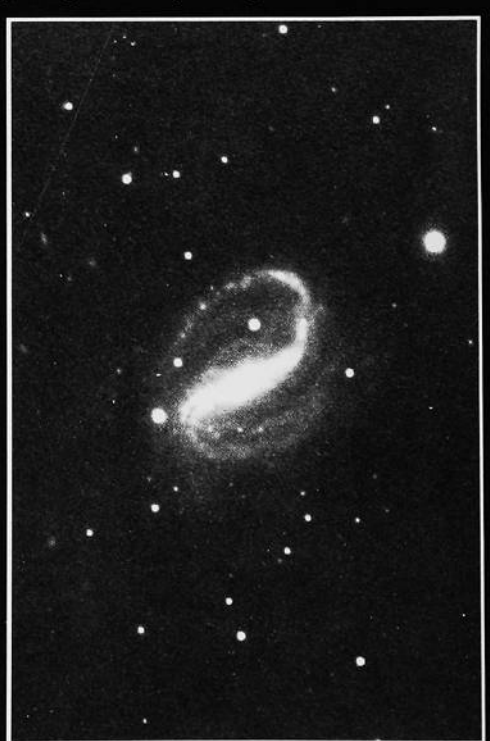
A 120-minute shot records four stars within the Owl Nebula in Ursa Major, as well as the object's famous "eyes."

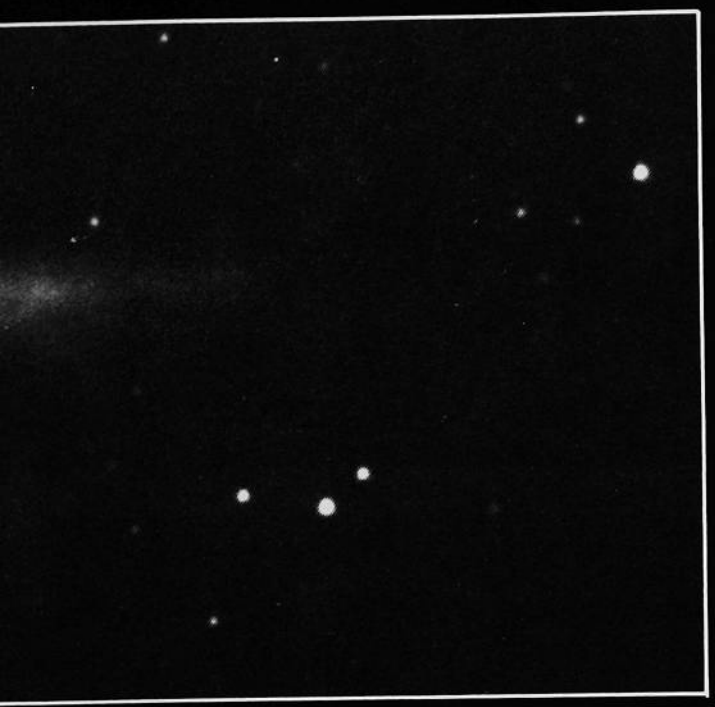
A tiny, starlike center and wispy spiral arms characterize NGC 6946 as it appears in a 120-minute exposure.

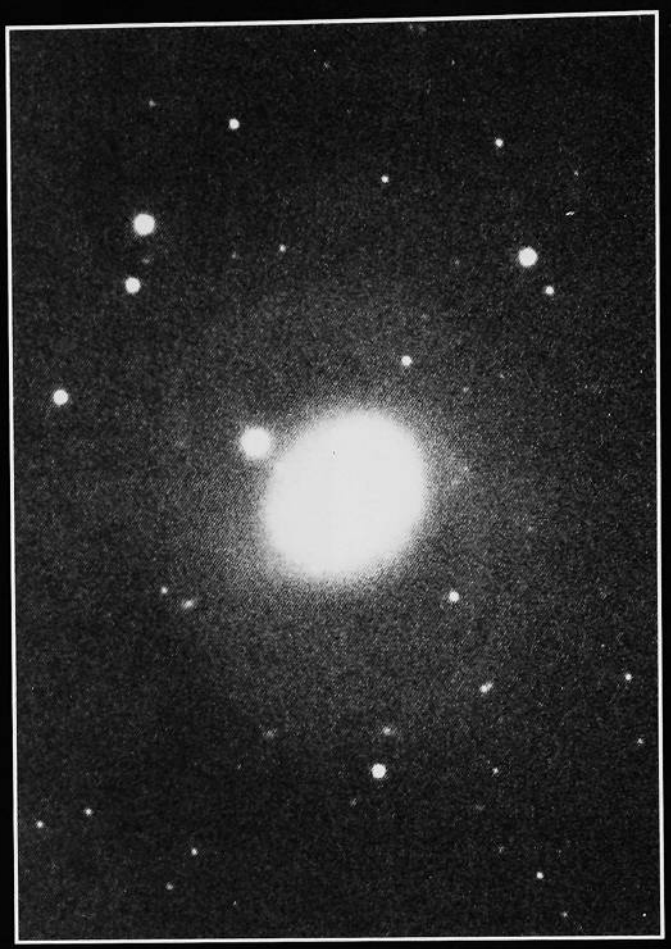
Reflection nebula NGC 7023 in Cepheus is a detailed mass of light in this 120-minute exposure.

A 150-minute exposure records the barred spiral arms of galaxy NGC 7479 in Pegasus.

Exposing for a mere 3 minutes resulted in this fine photo of the central portion of M42, the Orion Nebula.







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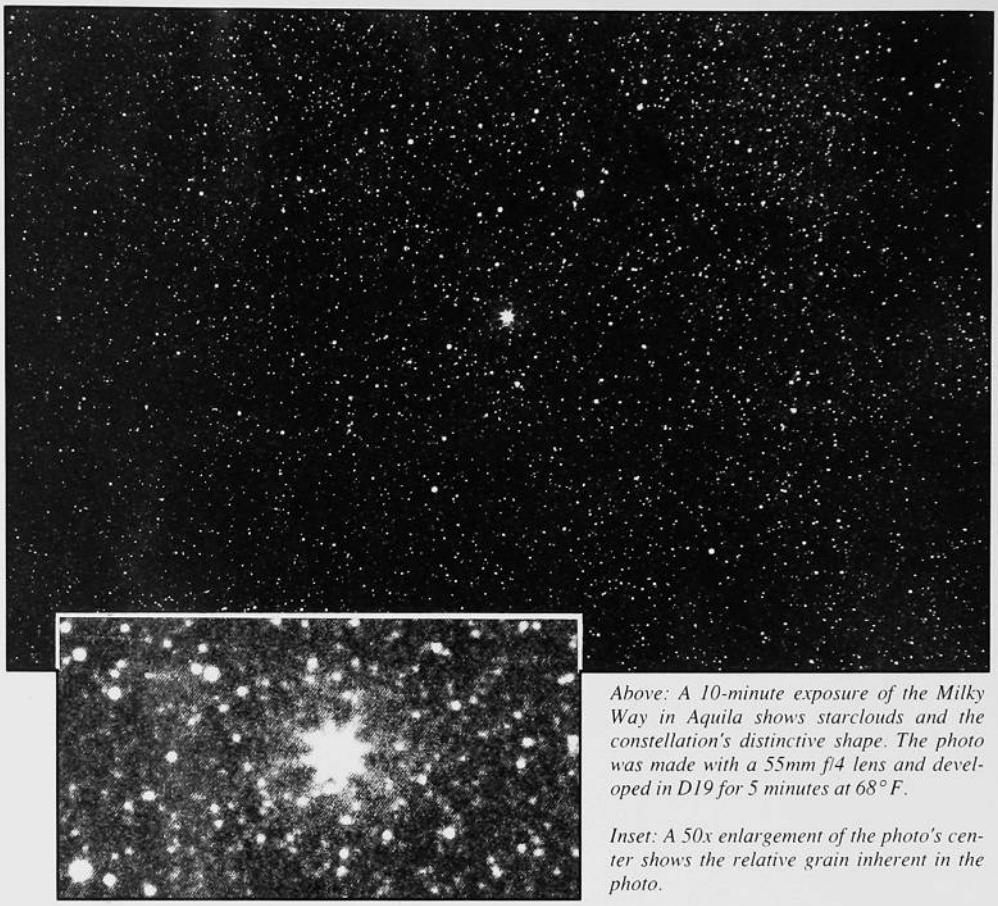
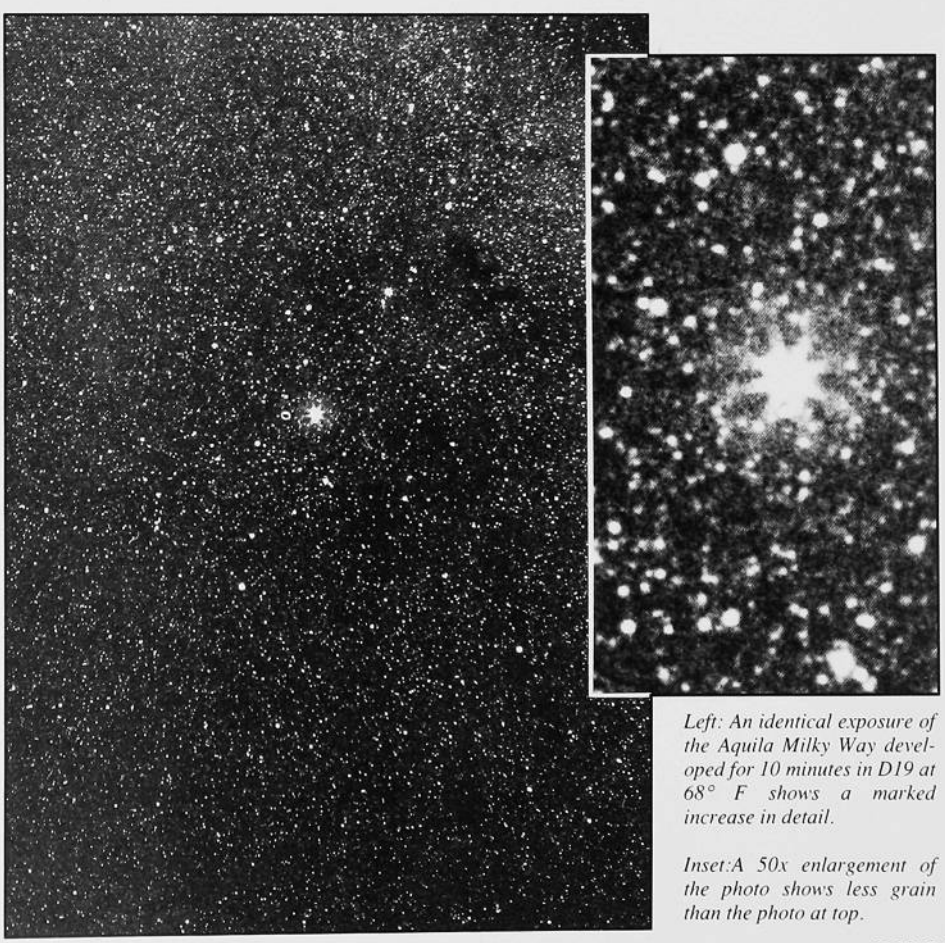


Above: A 10-minute exposure of the Milky Way in Aquila shows starclouds and the constellation's distinctive shape. The photo was made with a 55mm f/4 lens and developed in D19 for 5 minutes at 68° F.

Inset: A 50x enlargement of the photo's center shows the relative grain inherent in the photo.



Left: An identical exposure of the Aquila Milky Way developed for 10 minutes in D19 at 68° F shows a marked increase in detail.

Inset:A 50x enlargement of the photo shows less grain than the photo at top.

Faint reflection nebulosity surrounding bright stars north of the Orion Nebula shows well in this 100-minute exposure.

In their study, Conrad and colleagues found that film speed increased with developing times of up to 12 minutes. Beyond this point, fog increased rapidly while film speed remained about the same. Increasing developing time, like hypersensitizing time, results in increased fog. However, unlike hypersensitizing, longer developing times can also increase film grain.

To evaluate the trade-offs between speed, grain, and fog, I experimented with extended development of Tech Pan. Although Conrad and colleagues used 4-inch by 5-inch sheets of film baked in pure hydrogen, I wanted to test 35mm Tech Pan hypered in 8 percent forming gas.

First I hypersensitized a strip of Tech Pan at 47° C for three days and cut it in half. I placed each strip on to an enlarger baseboard beneath the acetate density step-wedge and exposed them to heavily filtered white light for 10 minutes. Each step attenuated the light, resulting in various exposures that could be calibrated using the known density of each filter. I developed one strip for 5 minutes and the other for 10 minutes. The resulting exposure densities were then determined using the densitometer. After subtracting fog, each density value was plotted against the corresponding relative exposure. This plot of density versus relative exposure is called the film's characteristic curve.

Characteristic curves can be used to determine differences in speeds by comparing the exposures required to reach a certain density. Comparing exposures needed to reach a density of 0.6 over fog, Tech Pan was 1.45 times faster when developed at 10 minutes rather than 5 minutes. Longer development results in a fog increase from 0.33 to 0.61, which requires that enlarger printing exposures be slightly longer to yield a comparable sky background. The net result is that Tech Pan hypered to a fog of 0.3 to 0.4, when developed for 10 minutes in D-19, is 45 percent faster than when developed for 5 minutes. Further experiments are necessary to determine whether baking time should be different if developing for 10 minutes.

Field Testing Optimized Tech Pan

To further evaluate speed gains from longer development of Tech Pan, I conducted tests at the telescope. To do so, I hypered a strip of Tech Pan and loaded two pieces of it into separate film cassettes. Using a 55mm f/4 lens, I exposed each frame on each roll for 10 minutes to the Milky Way in Aquila. I used a tracking equatorial mounting at a dark-sky site. Both strips were developed in D-19 at 68° F, one for 5 minutes and the other for 10 minutes. Thus both film strips were identical except for developing time.

Photographic prints made from the two negatives accompany this article, and the speed gain is obvious in the negative developed for 10 minutes. (Prints from the 10-minute development were exposed longer in the enlarger to compensate for increased fog density.)

While increased fog can be compensated for by using longer enlargement exposures, increased grain cannot be compensated for. More grain is evident in negatives as you develop Tech Pan for longer and longer times. However, this increased grain is barely noticeable in normal enlargements. Two of the Aquila photos enlarged 50x demonstrate the difference in graininess.

Tech Pan's developing time also relates to the focal ratio of the system you're using. In slow systems, such as f/10 Schmidt-Cassegrains, the ef-fects of slightly increased grain are much less significant than in faster systems. With my 11-inch f/10 SCT I have no problems exposing hypered Tech Pan for up to 3 hours and then developing it for 10 minutes. One of the nicest results was a 2-hour photo of M33 showing the galaxy's spiral arms resolved into stars. At the suggestion of Lowell Observatory's Brian Skiff, I searched the literature to determine the photo's limiting magnitude. By comparing this photo with photoelectric sequences published by Johnson and Sandage, I was able to identify stars down to 20th magnitude.

For fast systems like Schmidt cameras and telephoto lenses, it might be preferable to develop the film for 4 or 5 minutes because speed is not a problem. On the other hand, Schmidt photographs using red filters for long exposures of emission nebulae might benefit from extended development. Every astrophotographer should experiment with hypersensitization and develop routines to match the optics and objects photographed. As demonstrated by many astrophotographers over the years, the fine grain and high resolution of Tech Pan — coupled with optimized hypering — make it the best film for deep-sky astrophotography.

Kim Zussman is a periodontist who lives in Thousand Oaks, California. His astrophotographic techniques are featured in the June 1989 issue of ASTRONOMY.

Deep Sky Reports
Digging into the RNGC
by Tony Hohenbrink and Robert Bunge

Frustrated, the Super C8 owner looks down at his *Uranometria* chart and thinks back to the photograph of NGC 5053 in *Burnham's Celestial Handbook*. It was plainly visible in the photograph, but where is the darn thing in his field of view?

A few telescopes down at the star party another amateur pats himself on the back. NGC 5053 was a great test object for his just-finished 13.1-inch scope. The barely discernible waft of haze was a tough find. Nonetheless, the 13.1-inch scope owner convinces the 8-inch scope owner to walk over to the 31-inch scope and peek at NGC 5053 there. They find it in the 31-inch, but wait — is that supposed to be a globular cluster? What a crummy object!

Welcome to the backwoods of the *Revised New General Catalogue*. Twenty years ago amateur astronomers basically confined their deep-sky observing to the Messier objects. Oh, there were a few NGC objects on observing lists, but they were the relatively few bright ones with numbers everybody could pretty well recite from memory.

However, that was then and this is now. As big-aperture telescopes became increasingly available and publishers issued more sophisticated atlases and information, amateurs became increasingly aware of dimmer, less conspicuous objects that are visible from the backyard. As this trend continues, it's a good time to stop and ask ourselves a few questions about the *RNGC*, still the fundamental catalog for deep-sky observers.

The *RNGC* started life as the *General Catalogue*, a compendium of objects discovered visually by the Herschels and published in 1862 by John Herschel. In 1888 John L. E. Dreyer collected observations from numerous other observers and combined them with the Herschel list to produce the *New General Catalogue of Nebulae and Clusters of Stars*. One hundred years ago the *NGC* was the master list of all known nonstellar astronomical objects.

Some eighty years later, professional astronomers Jack W. Sulentic and William G. Tifft waded through the entire *NGC* and located each corresponding object on the Palomar *Sky Survey*. Sulentic and Tifft measured each object's location, attempted to determine its magnitude, and classified it into one of ten categories. In 1974 they published the results, called the *Revised New General Catalogue of Nonstellar Astronomical Objects*.

The making of the *RNGC* wasn't as simple as it may seem. Often several objects would show up on a plate where Dreyer had only listed one. Which object was Dreyer's? The old compiler included visual descriptions of objects in the *NGC*, but as all deep-sky observers know, any resemblance between a dim galaxy in the eyepiece and on a Palomar print is purely coincidental.

When Sulentic and Tifft became confused about which object was Dreyer's, they took the catalog number and assigned it to all potential candidates, tacking on a letter as a suffix. Thus you have RNGC 7801A, RNGC 7801B, and so on. That's why the *RNGC* catalog numbers extend only to 7840, even though the catalog contains 8,163 objects.

Actually, that should read 8,163 *entries*. Seven hundred ninety-nine of Dreyer's original objects, almost one in ten, were listed by Sulentic and Tifft as "not found." These objects either had bad positions, inaccurate descriptions, or for some other reason could not be positively identified on the survey plates by Sulentic and Tifft. They were included in the *RNGC* because of historical interest and because Sulentic and Tifft were in some cases themselves in error.

One of the biggest problems with the *RNGC* is its magnitudes. There are no magnitudes given for 2,037 objects — about one in four objects. However, this is not due to sloppiness by Sulentic and Tifft. They did not calculate magnitudes for greatly extended objects like emission and reflection nebulae and open star clusters. Naturally the objects listed as "not found" have no magnitudes given. Notwithstanding these classes of objects, there are still about one thousand objects with no magnitudes given.

There is also a strange group of 109 objects classified as "unverified southern objects." Sulentic and Tifft tried to cover the entire *NGC*, but in 1973 the Palomar plates did not extend below -45° declination. They managed to find all but 109 NGC objects south of that declination using other plates, but the 109 "missing objects" were never accounted for. In all likelihood these objects exist and should have been included.

Some objects have unusual object type numbers such as 19, 25, or 65. These denote special combinations of object type and associations with other important objects. A "19" object, for example, is an open cluster in the Small Magellanic Cloud. RNGC 206, a type 65, is an open cluster with associated nebulosity in the Andromeda Galaxy. RNGC 1049, type 25, is a globular in the Fornax dwarf galaxy.

Sulentic and Tifft used a strict definition of object-type codes when assigning them, so care must be taken when inter-

Statistical Breakdown of the *RNGC*

Object Type	Number	Average Mag.
Open clusters	329	8.7
Globular clusters	107	9.5
Diffuse nebulae	74	none
Planetary nebulae	98	12.1
Galaxies	6260	13.9
Clusters with nebulosity	22	none
Nonexistent objects	799	none
Objects in LMC	318	
Objects in SMC	35	
Unverified southern objects	109	none
Totals	8163	13.5

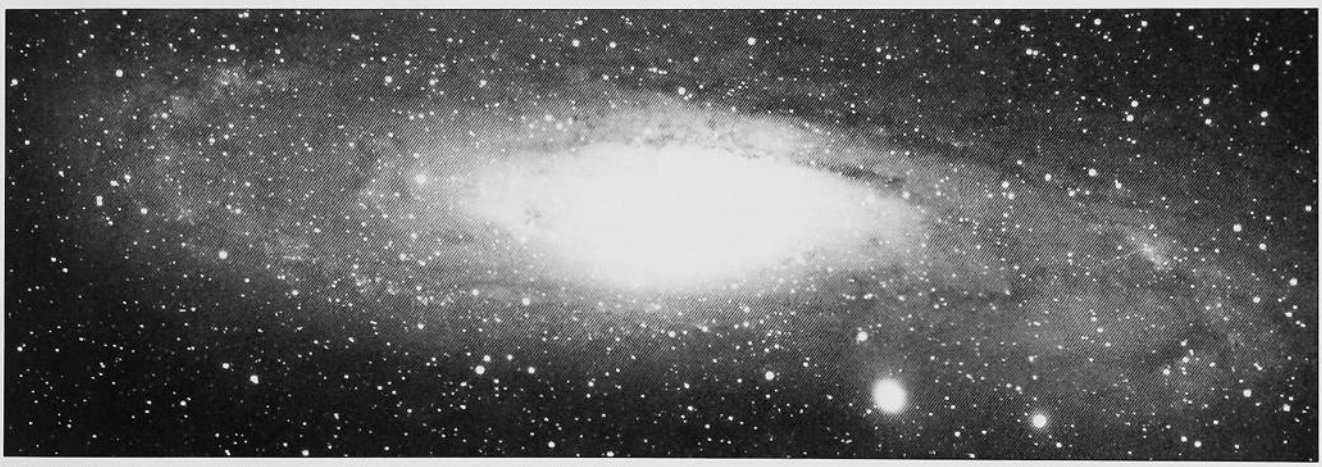
A Breakdown of *RNGC* Magnitudes

Magnitude	Objects
17 or fainter	10
16-16.9	67
15-15.9	1488
14-14.9	1982
13-13.9	1235
12-12.9	654
11-11.9	233
10-10.9	131
9-9.9	114
8-8.9	93
7-7.9	57
6-6.9	27
5-5.9	18
4-4.9	13
3-3.9	4
2-2.9	1

Notes: On the faint end, ten galaxies are listed at 17th magnitude. On the bright end, RNGCs 2451, 2516, 3532, and 6475 (M7) lie between magnitudes 3 and 3.9. NGC 1980, the open cluster south of the Orion Nebula, is catalogued at magnitude 2.5.

RNGC Statistics
By
Tony Hohenbrink and Robert Bunge

Dec. Zone	Type 0	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 18	Type 19	Type 25	Type 28	Type 29	Type 35	Type 38	Type 39	Type 65	Type 68	Type 69	Total Obj. This Zone
+90° to +75°		1				37 2		5 5												# Objects No Mag. No Dreyer No Palomar
+74° to +45°		69 10	1	7 7	15 1	801 20 42 1	4	94 94						5 5						Total=996
+44° to +15°		55 11	12	18 18	20 6	1945 74 81	4	199 199						4 4			1 1			Total=2258
+14° to -14°	1 1	59 6	19 1	26 26	21 5	2206 132 68 1	7 3	323 323												Total=2662
-15° to -44°	2 2	77 6	56 6	11 11	27 7	992 308 78	7	127 127			1 1									Total=1300
-45° to -74°	101 101	68 4	18	12 12	14 7	263 163 39		50 50	165 142	8 1		36 24	12 1		15 15	4 4		101 82	11 8	Total=878
-75° to -90°	5 5		1 1		1 1	16 13 1 7		1 1	1 1											Total=26
	109	329	107	74	98	6260	22	799	166	8	1	36	12	9	15	4	1	101	11	Total Obj's
	109	37	8	74	27	710	3	799	143	1	1	24	1	9	15	4	1	82	8	Total No Mag



M31, the Great Andromeda Galaxy, contains a starcloud (at far right in the galaxy's spiral arm) that carries its own RNGC *designation, RNGC 206. Photo by Martin C. Germano (6-inch f/8 refractor at f/5.3, hypered Tech Pan film, 65-minute exposure).*

Familiar as it may be, the Lagoon Nebula, M8, is listed in the RNGC *not as a nebula but as a cluster with associated nebulosity. Photo by Mike Sisk (24.5-inch f/6.2 SCT, Fuji R100 film, 53-minute exposure).*

preting them. For example, the Orion Nebula is listed as RNGC 1976, a cluster with associated nebulosity. Such is also the case with other objects we think of as nebulae, including M8, M16, M17, and M20.

Of course the classification of most RNGC objects is far more straightforward. In fact the great majority of objects, about 6,500, are galaxies with magnitudes between 13 and 14. The bulk of the RNGC objects lie in the Northern Hemisphere, which correlates with the Herschels' and other nineteenth-century observations.

Where does the *RNGC* go from here? Although it was a mammoth contribution to astronomical literature, the *RNGC* has its problems. Apart from identification problems, most of the magnitudes are unreliable, the old and revised descriptions are of little value to observers, and the coordinates used are for equinox 1975.0. There are many other errors in the *RNGC* from nineteenth-century and other sources. At least one professional astronomer, Harold Corwin of the University of Texas, is devoting his energy toward compiling an exhaustive list of all known *RNGC* errors.

As more modern, high-quality data gets compiled into catalogues a la *Sky Catalogue 2000.0*, the *RNGC*'s usefulness will slowly fade away. In time the catalogue may be chiefly a historical curiosity that links future deep-sky observers with the great, classic period of discovery of one and two hundred years ago.

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Deep Sky Reports
The Photography of Martin C. Germano
by David J. Eicher

Every few weeks over the past ten years, I've received a package that I treasure. It's the latest collection of prints from Marty Germano, one of the most prolific skyshooters in the history of amateur astrophotography. More than any other single person's photographs, Marty's material has formed the core of what we've published in *Deep Sky*. His ability to consistently shoot high-quality photos of both well-known objects and obscure nebulae — and the fact that he uses a reasonably small aperture scope — is a tribute to what amateurs can do for science.

At the end of last year I dug into a package from Marty and was even more astonished at the prints than I usually am. The subtle light of the Rosette Nebula spilled out first. Marty's photo showed an incredible range of tones in the Rosette nebulosity, from bright, sharp structure to an amorphous halo surrounding the entire object. Dazzling bright members of the cluster NGC 2244 filled the nebula's center, and incredibly detailed dark filaments danced about the central hole.

As are all of Marty's current photos, the Rosette shot was made with his 8-inch f/5 Newtonian reflector and hypersensitized Tech Pan film. In this case Marty used a typically long exposure time (90 minutes) and developed the negative in D19 for 7.5 minutes at 68° F.

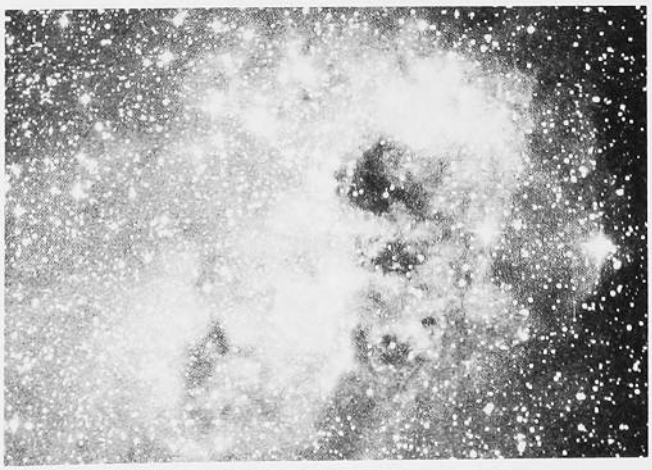
Before I was finished being impressed with the Rosette, more images passed before my eyes. The bright central arc of the California Nebula, exquisitely detailed, contained a single dark spot. IC 410, the faint nebula in Auriga associated with cluster NGC 1893, appeared saturated in Marty's 75-minute exposure. A deep shot of Orion revealed Barnard's Loop as a half circle and showed the Lambda Orionis cloud brilliantly. The central triangular section of the Veil Nebula, NGC 6979, had more detail than I'd ever seen before in an amateur photo.

The amazing images weren't limited to well-known objects, however. After reading David Higgins' article in *Deep Sky* #22 (Spring 1988), Marty tracked down and photographed the faint globular Palomar 13 beside galaxy NGC 7479. His photos of planetaries showed images of PK 217+14.1 and PK 205+14.1, the first amateur photos I'd received of these obscure nebulae. A 90-minute exposure caught central details of the extremely faint supernova remnant Simeis 147 in Taurus. And three shots portrayed Local Group galaxies IC 10, IC 1613, and the impossibly faint Ursa Minor Dwarf Galaxy.

Normally I don't run photos simply for the sake of running photos. But after receiving these stunning pictures, I couldn't resist.

Curving wisps of nebulosity are revealed in this 80-minute exposure of the California Nebula in Perseus. All photos are by Marty Germano and were made with his 8-inch f/5 reflector and hypered Tech Pan film. This shot was made at f/6 and developed in D19 for 7.5 minutes at 68° F.

A 70-minute exposure at f/5 shows an unusual pair of objects: galaxy NGC 7479 and Palomar 13, a remote globular cluster (left). This shot was developed in D19 for 7 minutes at 69° F.



A 75-minute exposure shows the complex region of bright and dark nebulosity IC 410, involved with the star cluster NGC 1893. This is an f/5 shot developed in D19 for 7 minutes at 69° F.

Orion is almost unrecognizable in this 90-minute exposure made with a 50mm f/1.8 lens guided on top of the 8-inch reflector. Marty used hypered Tech Pan film and developed it in D19 for 8 minutes at 68° F. Barnard's Loop and the Lambda Orionis Nebula are conspicuous. The streak at bottom is an airplane trail.

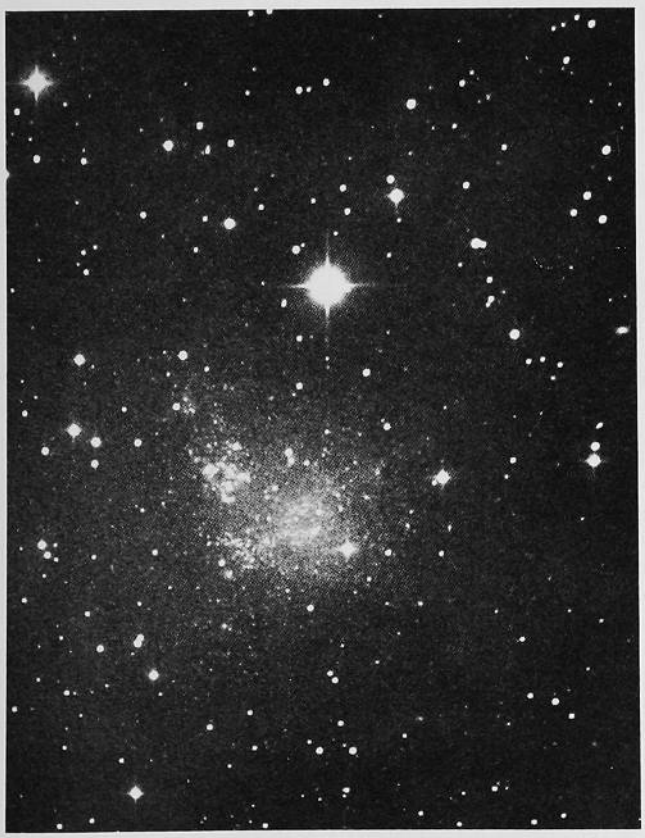
NGC 2395 is the loose, bright star cluster at top center in this 90-minute exposure at f/6. The loop-shaped planetary nebula at left is PK 205+14.1. This shot was developed in D19 for 7.5 minutes at 68° F.

No more than an amorphous glow in most telescopes, PK 217+14.1 is a detailed ring in this 70-minute exposure at f/5, developed in D19 for 8 minutes at 68° F.

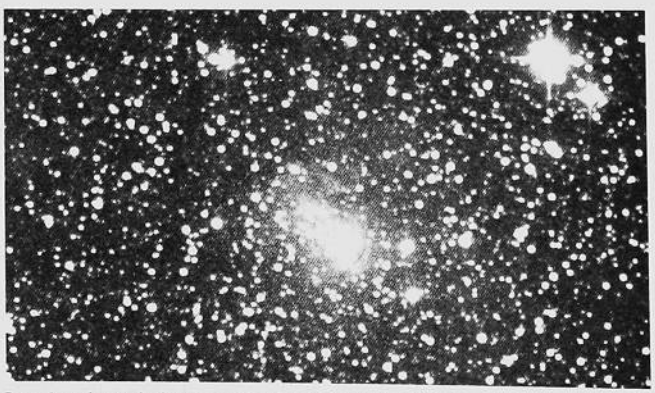
Probably invisible to the eye with any telescope, Sim 147 is one of the sky's legendary faint objects. The ancient supernova remnant in Taurus is visible in Mark's 90-minute exposure at f/5, developed in D19 for 7 minutes at 68° F.

Hot stars and swirling gas characterize the Rosette Nebula in Monoceros, beautifully recorded in a 90-minute exposure at f/6. The shot was developed in D19 for 7.5 minutes at 68° F.

Almost as faint as the sky background itself, the Ursa Minor Dwarf Galaxy is faintly visible in this 70-minute, f/5 exposure as a circular glow. The shot was developed in D19 for 6.5 minutes at 68° F.



The low surface brightness galaxy IC 1613, a member of the Local Group, is plainly visible in this 75-minute exposure at f/5, developed in D19 for 7.5 minutes at 68° F.



Bursting through the dense starfields of central Cassiopeia is the galaxy IC 10, another Local Group member. Marty recorded this galaxy in a 75-minute exposure at f/5, developed in D19 for 8 minutes at 68° F.

Deep Sky Reports
Summer's Challenging Deep-Sky Objects
by Phil Harrington

The variety of summer deep-sky objects is almost endless. Clusters, nebulae, and galaxies of all shapes and sizes can make it difficult to choose just where to start on a night's excursion into the universe. This column offers a selection of the summer's best planetary nebulae. Some require only binoculars or small telescopes to view, while others can be glimpsed only with large backyard instruments. Drop us a line at the address below and let us know how you did.

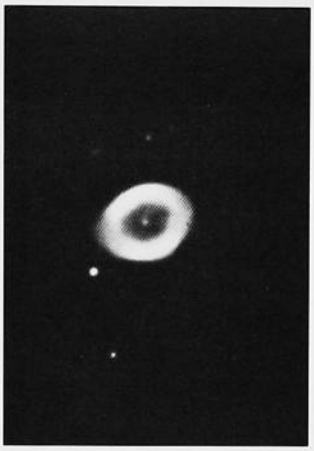
The Dumbbell Nebula photographed by Kim Zussman (11-inch f/10 SCT, hypered Tech Pan film, 70-minute exposure).

The Dumbbell Nebula: A Binocular Challenge

Stats: R.A. 19h57.4m, Dec. +22°35'. Constellation: Vulpecula. Magnitude: 8. Size: 8' by 5'.

Of all the planetaries in the sky, none is more spectacular than M27, the Dumbbell Nebula. Lying 0.6° south of the 6th-magnitude star 14 Vulpeculae, the Dumbbell is visible in 7x binoculars as a tiny rectangular puff of light set against a field of glistening stars. The nebula's greenish tint is perceptible in small binoculars, but only on steady nights. Large binoculars routinely show the nebula's greenish color and its distinctive hourglass shape.

If the current distance estimate of 975 light-years is correct, then M27 is one of the closest planetaries. Its dimensions of 8' by 5' correspond to an actual diameter of about 2.5 light-years. Curiously, studies show the Dumbbell has existed for some 48,000 years — more than twice as long as the evarage planetary nebula.



The Ring Nebula photographed by Paul Roques (8-inch f/10 SCT, hypered Tech Pan film).

Small Telescopes Reveal the Ring

Stats: R.A. 18h53.6m, Dec. +33°02'. Constellation: Lyra. Mag.: 9.7p. Size: 70".

M57, Lyra's famous Ring Nebula, is undoubtedly the most observed object of its kind. Its distinctive smoke-ring shape, high surface brightness, and easy location to find make M57 a favorite showpiece object at practically all summer star parties. Look for the Ring about one-third the way between Beta and Gamma Lyrae, along the southern side of the trapezoid-shaped star group that comprises Lyra's brightest stars.

Surprisingly, the Ring is visible in finder scopes, although its tiny diameter makes it appear like a fuzzy star. Increasing magnification to 25x reveals the nature of M57.

In fact, I can recall one of the first times I saw the Ring through a small telescope. It was with a friend's 2-inch refractor — you know, the kind that's advertised as delivering 400x. Under unusually steady conditions, we cranked the magnification up to about 200x without damaging the image quality too much. On that night, I had my first good view of the Ring. The oval shape of the little puff of light was clear as a bell.

NGC 6905 photographed by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 40-minute exposure).

Catch a Blue Flash with a Six or Eight-Inch Scope

Stats: R.A. 20h22.4m, Dec. +20°07'. Constellation: Delphinus. Mag.: 11.9p. Size: 46".

NGC 6905, the "Blue Flash," lies directly west of an asterism of 6th-and 7th-magnitude stars about 5° northwest of the diamond of Delphinus. While many planetaries are easily mistaken for stars, such is not the case with NGC 6905. My notes made with a 6-inch reflector recall an oval patch of blue-green light set in an attractive field of stars.

Eight-inch scopes show the nebula's 12th-magnitude disk surrounding a faint central star. Can you glimpse the central star and three faint stars that bracket the nebula on one side?

M15 photographed by Jay Anderson (8-inch SCT at f/5, 103a-E film, 20-minute exposure).

Peek into a Globular Cluster with a Large Telescope

Stats: R.A. 21h30.0m, Dec.: +12°10'. Constellation: Pegasus. Mag.: 14.9p. Size: 3".

The location of Pease 1 makes it one of the most difficult planetary nebulae in the sky. Lying inside the globular cluster M15, its location is easy to find but virtually impossible to pick out amongst the myriad stars in the cluster.

Pease 1 is the only example of a planetary inside a globular cluster. It was discovered in 1927 on photographs made with the 100-inch Hooker telescope at Mount Wilson, California.

Only the largest backyard telescopes stand a chance of showing this tiny object, as it glows dimly at 15th magnitude and is barely 3" in diameter. Still, given the right conditions, it may just be possible to visually detect. Search for Pease 1 on M15's northeastern edge.

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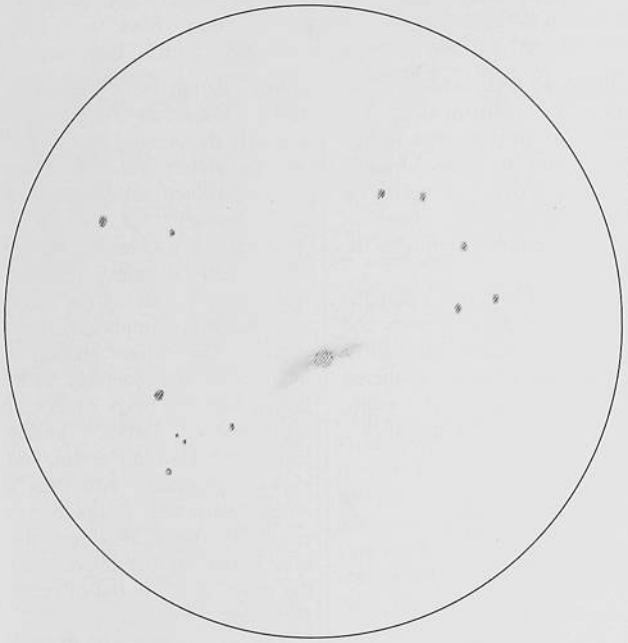
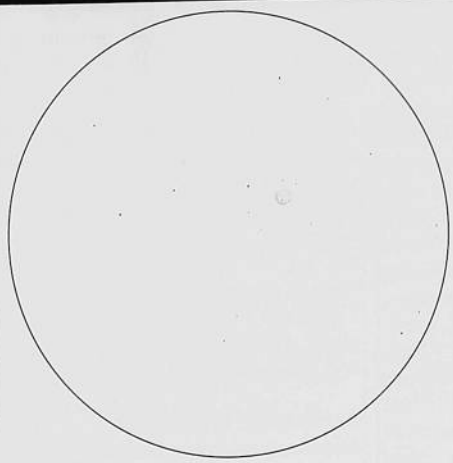
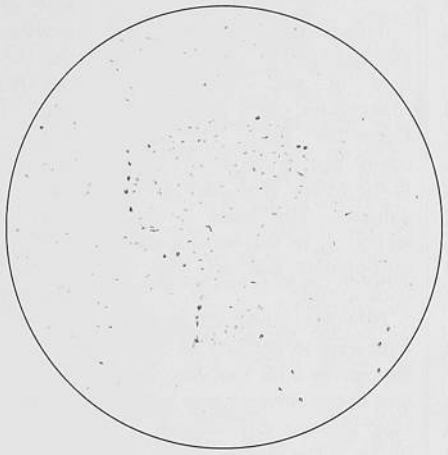
Deep Sky Reports
Reader's Page
by Steve Coe

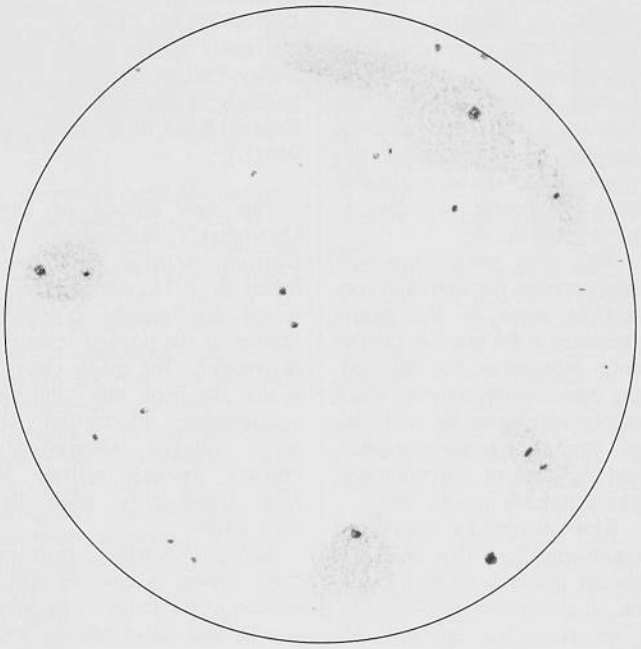




Left: Joe LaVigne of Naples, Florida, made this sketch of NGC 6302, the Bug Nebula. He used a 12.5-inch f/6 reflector at 145x.

Far left: Dennis Casper sketched planetary nebula NGC 6337 with an 8-inch f/10 SCT at 100x. He employed a UHC filter to boost contrast.





Right: A.J. Crayon of Phoenix recorded star cluster NGC 6451 using his 8-inch f/6 reflector at 115x.

Far right: Steve Coe sketched NGC 6334 using a 17.5-inch f/4.5 reflector at 100x. He used a UHC filter for the observation.

Last issue I presented a page full of challenging objects to observe in Scorpius, intending to blend in reader observations with my own and those of my friends here in the Phoenix area. I asked you to send observations to Dave for inclusion in this column, and the response was good.

What follows are my own notes and observations from some of you who responded. As we get more readers involved with this column, we can convince Dave to give us more space, and by sending in material you'll be virtually guaranteed some of it will be published.

For the autumn issue, send Dave observations of deep-sky objects in Pegasus. We're specifically interested in NGC 7448, NGC 7454, NGC 7469, NGC 7479, and NGC 7619-26.

Future issues will cover objects in Gemini, Leo, and Lyra.

Scorpius Objects

A trip to Australia in 1986 to see Comet What's-His-Name showed me that the Milky Way doesn't simply fade out below northern Scorpius. From Jim Barclay's backyard in Brisbane we observed six fabulous objects in Scorpius and saw them as we never had before.

NGC 6302, the Bug Nebula, is a bright, large planetary. This object is easily visible in a 17.5-inch f/4.5 telescope at 165x. Increasing the power to 320x brought out some fine detail and revealed the central star.

NGC 6334 is an irregular emission nebula spanning 30'. The nebula is faint and contains at least fifteen faint stars embedded within. There are four bright areas of nebulosity that peek out of the overall cloud.

NGC 6337 is a faint, large planetary nebula that is basically ring-shaped. At 320x there are two stars involved. A UHC filter bumps up the contrast considerably.

NGC 6357 is another emission nebula. Without the UHC filter, it is pretty bright, pretty small, and elongated east-west. With a nebula filter I can see faint filaments extending outward from this object.

NGC 6380 is a tough globular cluster. This object is quite faint and small, appearing 30" across at 220x. Averted vision helpsin spotting this object.

NGC 6451 is a bright, compressed open cluster that includes a pretty triple star. I counted fifty members in this group and observed a dark lane that bisects the cluster.

Deep Sky Reviews
Books for the Observing Season
by David J. Eicher

Astrophoto VIII Proceedings
John Sanford, ed.
46 pp., 8-5/8" by 10-7/8", paperback, $10
Orange County Astronomers Publications, Orange, California, 1989
[publisher's address: 2215 Martha Avenue, Orange, CA 92667. Price given is US ppd.; $12 foreign by surface mail or $15 foreign by airmail.]

On February 25, 1989, Southern California's Eighth Astrophoto Conference was held at California State University in Fullerton. Approximately every other year for a decade-and-a-half, the Orange County Astronomers and the Ventura County Astronomical Society have sponsored this event, which draws a sizeable crowd of people who love to photograph the sky.

This slim proceedings volume captures the spirit and content of some of the papers presented at the one-day conference. Altogether, ten outstanding presentations appear, which nicely summarize the activities of modern astrophotographers and the state of astrophotography as it heads into the '90s.

Kim Zussman's paper on optimizing Tech Pan 2415 is a similar presentation to his article in this issue of *Deep Sky*. (Our version has somewhat different material and a number of illustrative photographs, however.) Lee Coombs outlines a "new dimension" in astrophotography as he explains how to produce stereo-pair photos that yield a three-dimensional effect. John Ebersole's paper describes a bicolor technique for wide-field nebular photography. Hal Jandorf offers his thoughts on rephotographing slides and prints.

The memory of Al Lilge permeates this volume and clearly affected participants during the seminar itself. One of the country's great astrophotographers and one of Southern California's most active amateurs, Al died after a two-year battle with cancer on June 10, 1988. I visited Al at his observatory on Palomar Mountain in 1981 and remember well his charming, dry wit. He was a rare, talented force in amateur astronomy, and I hope that future astrophotographers will use Al's innovations and dedication as an example.

Astrophysics of Gaseous Nebulae and Active Galactic Nuclei
Donald E. Osterbrock
408 pp., 7-5/8" by 9-1/2", hardcover, $36
ISBN 0-935702-22-9
University Science Books, Mill Valley, California, 1988
[publisher's address: 20 Edgehill Road, Mill Valley, CA 94941.]

This new edition of Don Osterbrock's *Astrophysics of Gaseous Nebulae*, first published in 1973, offers a redirected and greatly expanded version of the popular research monograph. The major change is that the book now contains considerable information on active galaxies, Osterbrock's primary research activity at Lick Observatory since the early 1970s.

AGN, as Osterbrock calls the book, serves as both an introduction to the fields of gaseous nebulae and active galaxies and as a graduate-level textbook on these subjects. In fact, it is based on Osterbrock's courses for graduate students at the University of California at Santa Cruz.

The contents of *AGN* are straightforward: an introduction to the types of objects surveyed followed by chapters on methods of energy transfer within gaseous nebulae; spectral properties; a comparison of theoretical work and observations; dynamics of nebulae; the role of interstellar dust; the relationship of H II regions and galaxies, planetary nebulae, novae, and supernovae; and active galactic nuclei. The level of presentation is advanced and involves a fair degree of mathematics. The book is set in typescript from a laser printer but looks virtually like typesetting. A relatively small number of line diagrams and photographs highlight the text.

Anyone who wants a detailed discussion of the properties and behavior of nebulae and active galaxies, and who isn't bothered by intermediate-level math, should consult Osterbrock's fine book.

Dust in the Universe
M. E. Bailey and D. A. Williams, eds.
572 pp., 7" by 10", hardcover, $69.50
ISBN 0-521-35580-X
Cambridge University Press, New York, 1989

This volume is the published proceedings of a conference held at the University of Manchester in England in December 1987. The papers cover dust in the solar system, in the Milky Way, and in other galaxies. The level is rather technical, so that most amateur astronomers will not find this book useful.

However, advanced amateurs who want to keep up on what's happening with thoughts about dust in the universe may want to look through this volume at a library. (The cost probably precludes purchase for most observers.) The most relevant paper for deep-sky observers is the one on dust in the LMC, M31, M33, and the Milky Way by J. Lequeux.

Extragalactic Astronomy
B. A. Vorontsov-Vel'yaminov
724 pp., 5-5/8" by 8-3/4", hardcover, $285
ISBN 3-7186-0237-7
Harwood Academic Publishers, New York, 1987

This impressive reissue of a book originally published in Russian in 1972 and 1978 adds much to the field of professional extragalactic research. Boris Vorontsov-Vel'yaminov is surely the greatest Soviet galaxy researcher and one of the most respected astronomers of the century. *Extragalactic Astronomy* is a sweeping survey of the state of galaxy research that covers all areas and includes many important illustrations. The current edition is in English and contains additional material from American astronomers Debra Meloy Elmegreen, Harold Corwin, and Howard Bushouse. Kitt Peak's Nigel Sharp did a superb job editing the book. However, the text is not for beginners. And the price, $285, is out-of-reach for almost everyone.

The book begins with the history of extragalactic research and then provides a useful summary of the most important catalogues of galaxies — the *NGC*, the *Shapley-Ames Catalogue*, the *MCG*, the *CGCG*, the *UGC*, and de Vaucouleurs' *Second Reference Catalogue*. A concise description of galaxy properties follows.

The book's heart consists of explanations of distances and masses of galaxies, luminosity and structure of normal galaxies, the Local Group, constituents of galaxies, peculiar galaxies, galaxy groups and clusters, and quasars. Elmegreen has added supplements when needed in the back of the book.

Extragalactic Astronomy is an invaluable source of information on all types of galaxies. It is one of the best references on galaxies for an observer's bookshelf. However, its whopping price dictates that it is best consulted at the library.

The Guide to Amateur Astronomy
Jack Newton and Philip Teece
327 pp., 7-5/8" by 9-7/8", hardcover, $24.95
ISBN 0-521-34028-4
Cambridge University Press, New York, 1989

Few introductory guides have

been written for those who want to enjoy the stars. Not one has been written that addresses the sophisticated world of amateur astronomy that exists in the 1980s — until now. Jack Newton and Philip Teece's *Guide to Amateur Astronomy* is by far the best book of its kind to date.

The lethal flaw in most books of this sort is an inability to accept that beginners in skywatching are beginners in skywatching. The usual and almost inexplicable push to "do science" before even learning the constellations — something that caters to the authors and not the readers — is deeply woven into many introductions to astronomy. This is not the case with Newton and Teece.

"This book is an invitation to a great adventure," the authors begin. With a keen understanding of their audience and a friendly, noncondescending manner, they proceed to explain the fundamentals of observing. Telescopes, mountings, eyepieces, accessories, and the basics of solar system and deep-sky observing all come alive. I was particularly happy to see a section devoted to astronomical drawing — something that has been almost universally ignored.

The second chapter serves as a beautiful guide to the wonders of the sky. Here beginning backyard observers can see the best and brightest galaxies, nebulae, and clusters in spectacular photography by Newton. Most of the images are black and white, although an insert with twelve color plates showcases some of the sky's best nebulae. The authors provide a listing of bright objects and a compact atlas showing these objects' positions relative to bright stars.

Observing projects get the spotlight in the following chapter. After a straightforward explanation of Universal Time, Newton and Teece suggest some slightly more sophisticated ways to observe the Sun, Moon, and planets and describe how to find and track asteroids and comets. Double stars, variable stars, and stars close to us in the Galaxy are also described. The section concludes with an introduction to astronomy clubs and star parties.

The book's final two chapters very nicely present readers with the basics of astrophotography and the fundamentals of building astronomical equipment. Much of this material draws on Newton's and his friends' own experiences, which makes the story rich with interesting details.

Newton and Teece have made a valuable addition to the world of astronomy books. Finally, we have a book that can be recommended to beginners, without hesitation, as a valuable guide to beginning their exploration of their night sky.

Pathways to the Universe
Francis Graham-Smith and Bernard Lovell
239 pp., 7-5/8" by 10", hardcover, $24.95
ISBN 0-521-32004-6
Cambridge University Press, New York, 1988

Pathways to the Universe is an introduction to astronomy by two of Britain's most distinguished astronomers. Francis Graham-Smith is England's Astronomer Royal. He has had a long and successful career as a radio astronomer that includes directorships of Jodrell Bank and the Royal Greenwich Observatory. Bernard Lovell is also known as a great radio astronomer and is now Emeritus Professor at the University of Manchester, having retired as director of Jodrell Bank in 1981.

"The answers to the great questions — what is the universe and what is our place in it? — often seem to be hidden in mathematics or astrophysical theory," the authors contend in their introduction. The text that follows introduces skywatchers to the wonders of the heavens in a way that anyone can relate to. "The first step in astronomy is easy," they write. "Choose a clear night and a comfortable place to lie or sit and look at the stars for half an hour or so. A few bright stars can be seen immediately; within five minutes the eyes become dark-adapted and we can see hundreds or even thousands more."

Sections that follow describe various objects in the sky that can be seen by backyard telescopists. The Moon, Sun, planets, comets, meteors, the Milky Way, variable and double stars, supernovae, galaxies, and quasars are all discussed. In addition to a general guide to observing the objects, the authors provide an overview of the physical properties of the objects and their current status in astronomical research. Final chapters outline cosmology and the origin of life.

Pathways is a curious blend of introduction and brief textbook that does a commendable job of introducing novice readers to the wonders of the sky.

Stargazers: The Contribution of Amateurs to Astronomy
Storm Dunlop and Michele Gerbaldi, eds.
237 pp., 6-1/2" by 9-1/2", paper, $29.50
ISBN 0-387-50230-0
Springer-Verlag, New York, 1988

Stargazers is the proceedings volume from Colloquium 98 of the International Astronomical Union, held in Paris in mid-1987. The IAU gathered in Paris to discuss the role of amateurs in astronomy. About 250 participants, both amateurs and professionals, attended from 27 countries. Guests presented papers on wide-ranging subjects in astronomy, all incorporating what amateurs are doing for "real" astronomy. The volume that records what went on there is quite interesting and revealing for a variety of reasons.

In their preface, editors Storm Dunlop and Michele Gerbaldi explain that publishing in full all 128 entries would have been impossible. Therefore, many of the papers are presented as brief abstracts. Others appear in some detail and allow a fine analysis of what happened at the Paris meeting. The book is partially typescript and partially typeset and contains a small number of illustrations.

Stargazers contains a marvelous cross-section of topics, separated into categories of history, observational methods, observations and results, and popularization. In the historical section we see such diverse topics as the instruments of Horace Dall, a profile of Johannes Hevelius, and amateur astronomy in France in the early nineteenth century. These papers are full of enthusiasm and vigor because they generally reflect times when amateurs were making hugely significant contributions to astronomy.

Observational topics include contributions of amateurs to variable star observing, amateur astronomers and the *Hubble Space Telescope*, the effects of light pollution on amateur astronomy, and amateurs and the search for supernovae. Popularization gives us such topics as astronomical publications, planetarium astronomy, teaching astronomy in schools, and the activities of astronomical clubs.

Generally this book is quite interesting to page through. While not uniform or always relevant to one's own astronomical activities, the papers present a wide array of information on what different people and different groups are actively doing.

However, the book is not for everyone. The papers are generally written in a pseudoscientific style, as if they are intended to be published in a scientific journal. The book's tone is strongly biased toward an "amateurs should make a contribution toward real science or they're no good" attitude. At some point, you get the feeling that if you're not out there every night taking data for the grand onward march of science, you're no damn good. Absolute nonsense!

The fact that this feeling permeates nearly all of the papers is more than a little distressing. Self-deceptions and science play aside, amateurs are amateurs who enjoy astronomy as a hobby, and professionals are paid collectors of data on the universe. Rarely do the two meet and understand each other.

I enjoyed *Stargazers* very much. It is a highly successful book for a select few. What I would like to see, however, is a companion volume that explores what's going on in the type of amateur astronomy practically all amateurs really practice.

Small Scope Showcase

Summer Observing Delights

by Alister Ling

With a sigh of contentment, I gaze once again along the length of our Galaxy. There is no doubt that I am a Milky Way observer. It's tough to beat the vast expanses of clusters, nebulae, and extremely rich starfields that inhabit the summer skies.

City-bound amateurs who had a difficult time galaxy hunting during the spring now have it easy. The number of observable Messier objects suddenly seems endless. I find it helpful to make a list of what I should be able to see and try to observe them all. Be aware that one season may not be enough time! Simply pour over your *Sky Atlas 2000.0* and *Burnham's Celestial Handbook* for some eye-catchers.

At the top of the list lies **M57** (NGC 6720), the Ring Nebula in Lyra, a great start to any observing session. Your next-door neighbors may have trouble detecting this faint puff of gray smoke. However, you can help them see this wonder by demonstrating a few tricks. The first thing is to have them cup their hands over their eyes to make sure porch and street lights are not interfering.

The next observing trick is increasing the magnification. Not only will this darken the sky background, but the Ring will also become bigger (and more appealing to your neighbor). Finally, a light pollution filter snaps the nebula into prominence. Remember to keep those hands cupped! See if you can spot the Ring's elongated appearance and elusive central star.

A truly impressive target for everyone is **M11** (NGC 6705), the Wild Duck Cluster in Scutum. Don't be afraid to use high powers on M11. This darkens the field enough to bring dozens of fainter stars into view, making M11 quite spectacular.

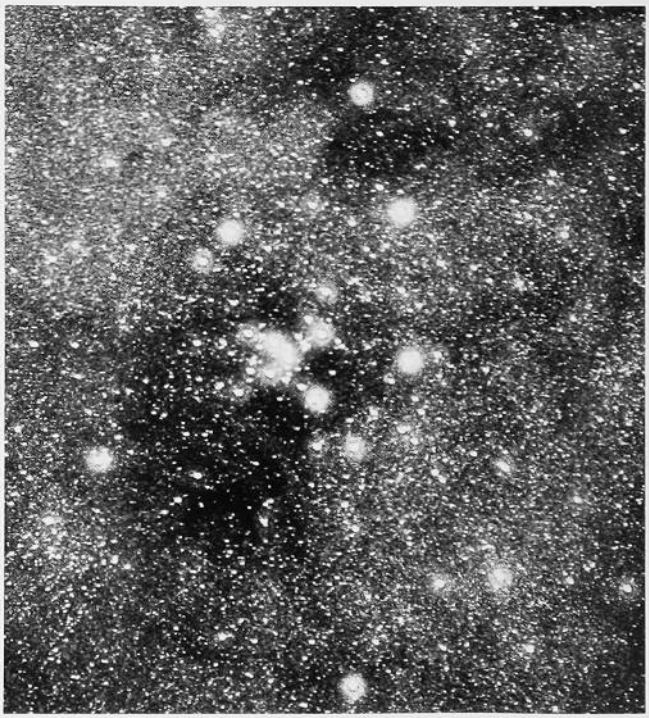
M11 is arrowhead-shaped. The bright star at the arrowhead seems to lead the flock through the eyepiece. While low powers display a dramatic field of tightly clustered stars, high powers show that the stars are not distributed evenly. I was struck by the large number of dark lanes dividing the cluster into clumps. But how could I record this fascinating view? Plotting the stars one by one was out of the question, because I simply don't have that sort of stamina.

Instead, I hit upon the idea of sketching the structure as a whole, rather than a mass of glittering stars. The accompanying sketch is the result of my "wire-frame" analysis. The cubist drawing captures a rather unique facet of M11. Why not try this technique on any object that you would otherwise consider difficult to represent on paper? I think you will surprise yourself.

Two other clusters that pierce the light shroud of cities are **M7** (NGC 6475) and **NGC 6231**, which are located in Scorpius. Both are filled with dozens of bright stars with little color differences. From a suburban backyard in Australia, I once nearly mistook NGC 6231 and its larger companion cluster Harvard 12 for Halley's Comet, which was of similar brightness, size, and orientation. With the help of binoculars, however, I could tell which of the two fuzzy blobs was the infamous comet.

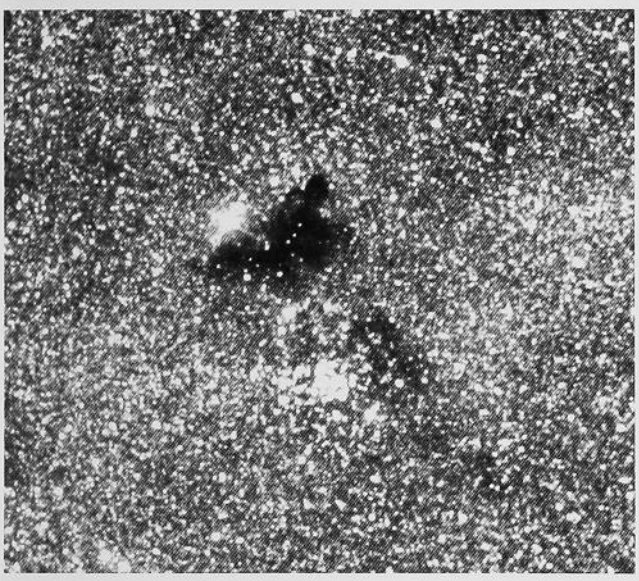
M7 can be a tough customer from northern latitudes. From just east of the Canadian Rockies in Edmonton, a friend found out that M7 at its highest reaches a mere 1° above the southern horizon. No amount of effort could ferret out this superb cluster from the northern latitude, but a trip south brought M7 into easy naked-eye sight.

To get the most out of summer observing, your best bet is to head out to dark country skies. Small scopes perform exquisitely there. Almost every



Top: Located in the heart of the Scutum starcloud, M11 is one of the finest open clusters in the summer sky. Photo by Martin C. Germano (8-inch f/5 reflector, hypered Tech Pan film, 30-minute exposure).

Above: Open cluster M7 is so bright that it is visible to the naked eye on dark nights. Photo by Jean Dragesco (105mm f/5.6 lens, 103a-E film, 20-minute exposure).



Top: NGC 6231 is composed of bright, blue-white O and B stars. Photo by Martin C. Germano (8-inch f/5 reflector, hypered Tech Pan film, 20-minute exposure).

Above center: Open cluster NGC 6520 lies adjacent to the extremely opaque dark nebula Barnard 86. Photo by Martin C. Germano (8-inch f/5 reflector, hypered Tech Pan film, 25-minute exposure).

Above: NGC 6603 is sometimes confused with M24, the large starcloud in which it lies. Photo by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 60-minute exposure).

field along the Milky Way is a sight to behold, but one of the prettiest is surely the one containing star cluster **NGC 6520** and dark nebula **Barnard 86**. They are located about halfway between the spout of the Teapot asterism and the Lagoon Nebula, M8.

B86 is one of the darkest, inkiest spots in the Milky Way. Its dust completely obscures the stars behind it. NGC 6520 is a compact open cluster just east of B86. The two fit comfortably in a low-power eyepiece.

After viewing the pair at low power, switch to higher magnification. The additional fainter stars make Barnard 86 more prominent. At the same time, you can enjoy a nice view of NGC 6520 because it is now clearly resolved into stars. Once you adjust to this higher power, you may wish to go on a tour of nearby dark nebulae.

However, don't grab a star atlas. Forget about atlases for the moment. Just let your eyes wander across the scene and look for a small "lane" of darkness leading away from B86. Follow it slowly. Before you know it, you will have stumbled on another dark nebula with a "lane" similarly attached. Continuing on, yet another dark nebula enters the field. Keep going. Medium powers make this tour all the more startling.

Further north in Sagittarius are **M24** and **Barnard 92**. Spend some time examining these two objects and their surroundings. There are many similarities and some important differences between these and B86/NGC 6520.

The two Barnard nebulae are similar in size and opacity. Note, however, the 12th magnitude star that seems to shine through B92. Like the area around B86, the M24 region also contains other dark nebulae connected by starless lanes.

M24 is a starcloud. Its stars are not gravitationally bound in the same sense as those in the open cluster NGC 6520. What we have here is simply the superposition of countless stars crowded toward the galactic center. Dust clouds located relatively nearby define the edges of the cloud and make it really stand out.

One way of appreciating the incredible density of stars in this location is to use enough magnification to isolate a section of the starcloud. Now slowly push your scope in any direction and watch the cascade of stars suddenly die. Just as astounding, you can start by centering on Barnard 92, a field that looks like any other in Pisces, and slide the telescope into a myriad of glittering points. Breathtaking!

M24 contains another treasure: the open cluster **NGC 6603**, occasionally thought to be M24 itself. (Fortunately, few references now make this mistake.) Messier explicitly stated that the size of his object was a degree and a half — three Full Moons! The 4' diameter of NGC 6603 hardly fits Messier's description.

At first glance you could mistake NGC 6603 for a comet. Experience tells all amateurs to take a look at higher powers, whereupon the fuzzy blob will resolve into stars in an 8-inch scope.

Summer's equivalent of the Great Orion Nebula is **M8** (NGC 6523). Unfortunately, city skies do a good job of wiping out the nebulosity and leaving only the embedded open cluster NGC 6530 shining through the veil of light. However, a very narrow band nebula filter, such as a UHC or O III, can rescue the nebulosity from oblivion. Remember that these filters are for visual use because they do not transmit the familiar red glow of Hα seen in photographs.

The view of M8 from dark skies is phenomenal. The nebula filter not only enhances the brighter nebulosity, but also brings fainter nebulosity into view, which you thought could only be seen on photographs.

Enjoy your view of all these summer delights, and continue as long as you can: summer nights are brief and the treasures are many. However, don't feel like you need to rush and see everything in one season. The Milky Way will still be there next year, and I know you'll be going back for more.

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Double Stars
Stuff
by Brian Skiff

My card file shows that I have observed sixty double stars in Lyra, the most interesting of which are described in the article on page 10. Rather than bore you with the uninspiring dozens omitted, I'd like to take this opportunity to answer a question often put to me: Where do you get all this stuff? Can you give me a list of basic references of information about double stars?

Unfortunately the answer is not a simple one. The best and most recent data, such as magnitudes, spectral types, and micrometric measures, are found in widely circulated professional journals such as the *Astronomical Journal* in the United States and *Astronomy & Astrophysics* in Europe. More information can be found in books containing the proceedings of a conference, which might not necessarily deal strictly with double stars. Yet other stuff is buried in relatively obscure places hard to dig out of even a well-stocked observatory library.

For a start, there is no better source of information about doubles in one place than *Sky Catalogue 2000.0, Volume 2* (*SkyCat2*) by Hirschfeld and Sinnott. It contains a wealth of information with which to generate observing lists, find unknown pairs, and look up ephemerides for orbiting pairs. To be sure, as is inevitable with any astronomical catalogue, its contents are becoming progressively out of date. But for the purposes of most casual observing, it is entirely satisfactory. If you're a beginner who wants to get into double stars, I recommend it highly.

The double star section of *SkyCat2* is derived from the 1975 edition of the *Washington Visual Double Star Catalogue* (*WDS*), now maintained at the U.S. Naval Observatory in Washington. The 1975 edition was a partially revised version of the more well-known Lick Observatory *Index Catalogue of Double Stars* (*IDS*), which was published in 1962.

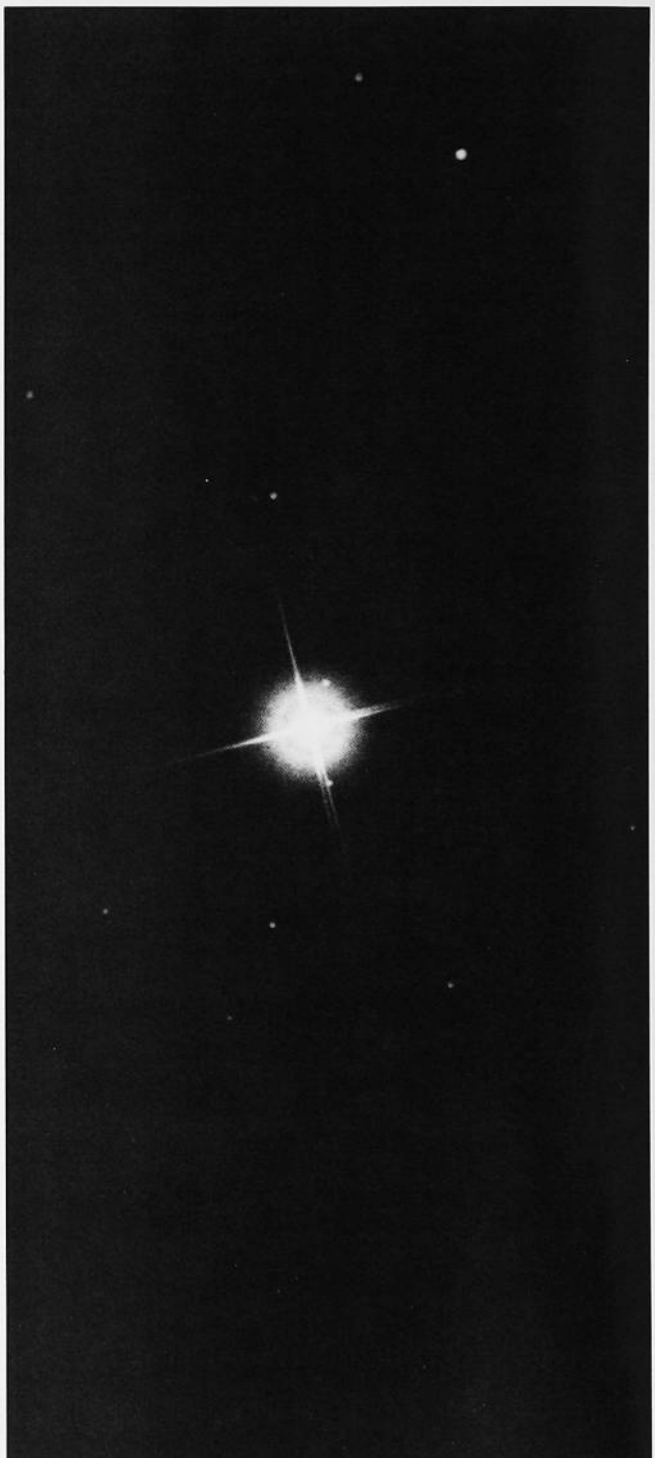
Both of these catalogues are now superseded by the 1984 edition of the *WDS*. There is no printed version: it is only available on magnetic tape or floppy disks. The *WDS* contains nearly 75,000 entries that summarize over a million individual observations published up to the end of 1983.

The *WDS* contains positions, first and last measures of separation and position angle, magnitudes, and star catalogue identifications for each pair. It is intended as a finding list for observers, not as a source of astrophysical data such as photometry or spectral types. Thus, someone wishing to measure double stars neglected by other observers can scan the *WDS*, looking at the dates of the last measure for unobserved pairs over a given interval (shorter for close pairs, longer for wide pairs).

The *WDS* lists separations to one-tenth of an arcsecond. For close pairs, especially under one arcsecond, this is not precise enough. These close pairs often exhibit such rapid motion that even the last measure (typically a decade old) is obviously not current — something you can tell when you observe it.

Several close pairs have orbits determined from an analysis of all available measures. Some of these are published piecemeal on *Circulaires d'Information* from Nice Observatory in France, which I discussed in the Autumn 1988 issue. Others appear in regular journals, particularly the *Astronomy & Astrophysics Supplements*, which has become a repository of papers on orbits. Some recent papers are listed in the bibliography.

A critical compilation of orbits is issued occasionally, most recently (1983) by Charles Worley of the U.S. Naval Observatory and Wulff Heintz



Although it is rarely observed because its components vary greatly in magnitude, Lyra's brightest star, Vega, is a triple star. Martin C. Germano's photo shows the star and its optical components near the bright diffraction spikes. The primary shines at magnitude 0.0, the components at magnitudes 11.0 and 9.5. Germano used an 8-inch f/5 reflector, Plus-X film, and a 5-minute exposure.

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Abt, Helmut. "The Ages and Dimensions of Trapezium Systems." *Astrophysical Journal* **304** (1986): 688.

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of Sproul Observatory at Swarthmore College. It contains orbital elements and other information for 847 systems, sometimes with more than one solution for a particular pair. Each orbit is graded in terms of a five-step quality scale. About half are reliable and not likely to be changed much as new observations are made. The remainder are preliminary or "indeterminate," a nice way of saying they're probably seriously wrong. The latter are nearly all pairs with orbital periods of hundreds or thousands of years that have moved but little during their observational history.

Worley and Heintz give orbital elements but no ephemerides for particular dates. The prevalence of home computers makes a separate publication for this unnecessary, although it might be handy and instructive. In any case, ephemerides can be found in *SkyCat2*, though not always based on the most recent orbit.

There are still many thousands of pairs up to 2" separation that have significant motion but not a long enough observational history for an orbit to be defined. To get recent measures for these, you must turn to the periodical literature. Prolific observers include Paul Couteau and Heintz. Heintz's lists invariably appear in the *Astrophysical Journal Supplements*, while Couteau's are in the *Astronomy & Astrophysics Supplements*. Measures of generally very close pairs obtained using the technique of speckle interferometry by Harold McAlister's group at Georgia State University are published in the *Astrophysical Journal*. Some recent publications are listed in the bibliography.

What about magnitudes and colors? Again, there is no general compilation in one place, and we must go hunting through the literature. A primary source for fairly wide pairs is Ake Wallenquist's *Catalogue of Photoelectric Magnitudes and Colors of Visual Double and Multiple Systems*. It contains data from various sources for over one thousand systems. Another important source of measures are those obtained using a narrow slit scanned across a pair, the profile of light intensity being analyzed to produce magnitudes (or differences) and astrometry. Two large sources of such photoelectric-scanner photometry are by a group led by Karl Rakos and by Hurly and Warner. These and other major papers are given in the bibliography.

Together with photometry, spectral types allow one to assign a "true" color for the components of double stars. The most thorough work along this line has been done by Helmut Abt. He is classifying all the *ADS* pairs with primaries brighter than 8th magnitude. Occasionally, the components can be observed separately by the spectrograph, but mostly the spectral types are for the primary only (for unequal pairs) or the combined light of close, nearly equal pairs. Types for about two thousand pairs have been published so far. For 170 pairs in the south observed with the photoelectric scanner by Hurly and Warner, spectral types have been determined by Christopher Corbally. His paper reproduces Hurly and Warner photometry and provides extensive notes on the studied pairs.

There's still more, of course: the literature on double stars is rich. The problem is finding out "everything" that's known about a certain pair. As with other areas of astronomy, it is easy to ask simple questions for which no answer can be found in the journals. Sometimes you just have to go to the telescope and make the necessary observations yourself (see, for instance, this column in the Summer 1988 and Winter 1988/89 issues).

The best thing you can do is to go to a large university library and look up some of the papers listed here. This will give you a feel for what is in each paper and how it is presented. The citations listed in the bibliography will give you a good start in locating information about double stars. The reference lists in each of these papers will lead to other material, and before you know it, you'll be the expert on the data sources!

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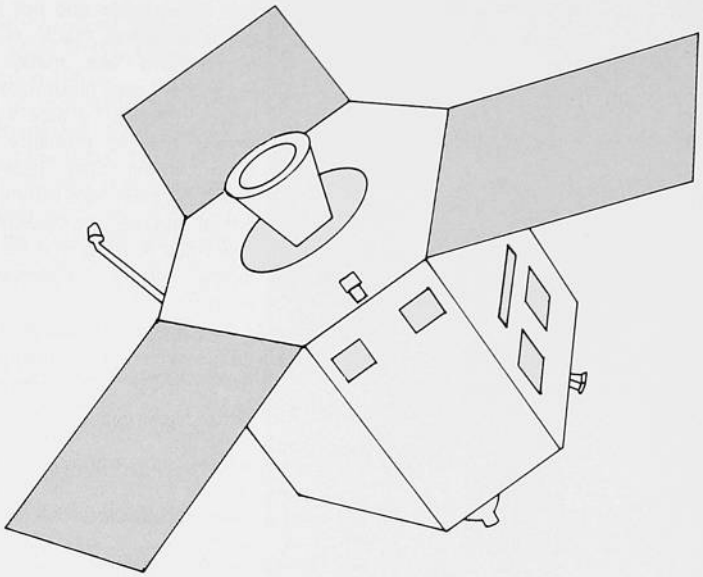
Variable Stars
Visual Observations Needed by Hipparcos
by David H. Levy



Hipparcos, *recently launched by the* Ariane 4 *booster, will do precision astrometry of variable stars and other objects.*

About the time you begin reading this article, *Ariane 4*, launched by the European Space Agency, will be speeding upward with a precious cargo, a new satellite. The satellite, called *Hipparcos*, will record precise astrometric positions of many different types of stars. Included in these stars are nearly three hundred long-period and semiregular variables; and the data returned by *Hipparcos* will be an invaluable help in studying these important objects.

An acronym for *High Precision Parallax Collecting Satellite*, *Hipparcos* will greatly benefit astronomers' knowledge of variable stars. According to Janet Mattei, director of the AAVSO, "The satellite's high-precision astrometric measurements, 100 times more accurate than any presently existing, will improve luminosity, mass, and radius determinations of these stars and will provide essential data for the study of stellar structure, evolution, and kinematics."

Satellites have done a great deal for variable star astronomy. For example, at the AAVSO Fall Meeting in 1978, attendees heard reports of how the High Energy Astronomical Observatory *HEAO-1* recorded x-rays from cataclysmic variable stars such as SS Cygni. The satellite recorded SS Cygni's outbursts as well as it did because visual observers alerted Mattei, who in turn called the research team and informed them that SS Cygni might be a prime target for *HEAO-1*.

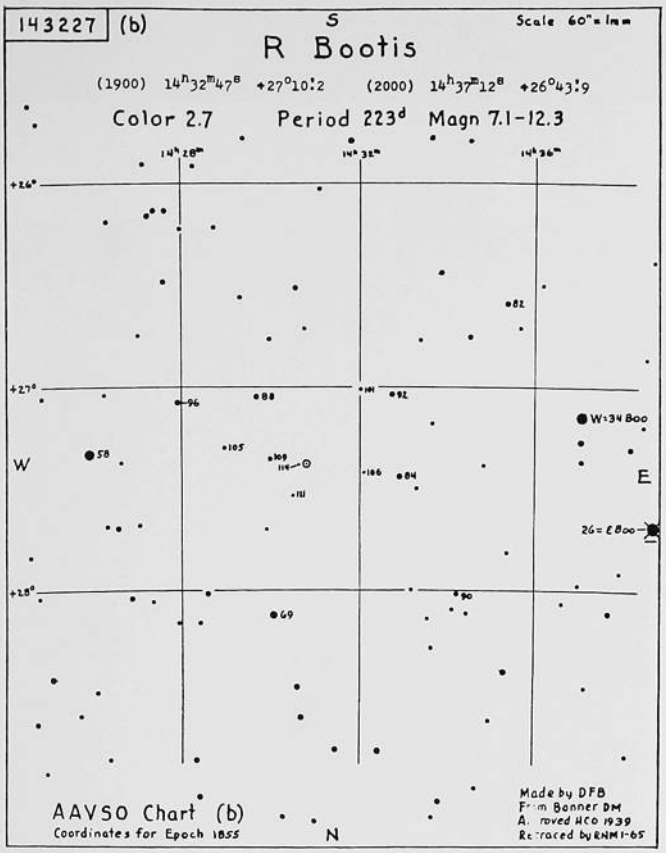
Other satellites, especially the long-lived *International Ultraviolet Explorer (IUE)*, have also made extensive use of AAVSO observations of dwarf novae. Over the years, AAVSO's archives have kept the professional community aware of the fluctuations of many variable stars. Because of these satellites, the AAVSO's work has entered the forefront of variable star research.

Hipparcos offers observers another chance to get involved with variable star astronomy via satellite. Information on the behavior of variable stars communicated to the AAVSO will be passed on to the science team working with the satellite. As with earlier satellites, data obtained from visual observers will be used in scheduling variable star observations on *Hipparcos*. Because *Hipparcos* cannot effectively measure a star fainter than 12th magnitude, the AAVSO will provide monthly data on the status of the 276 program stars.

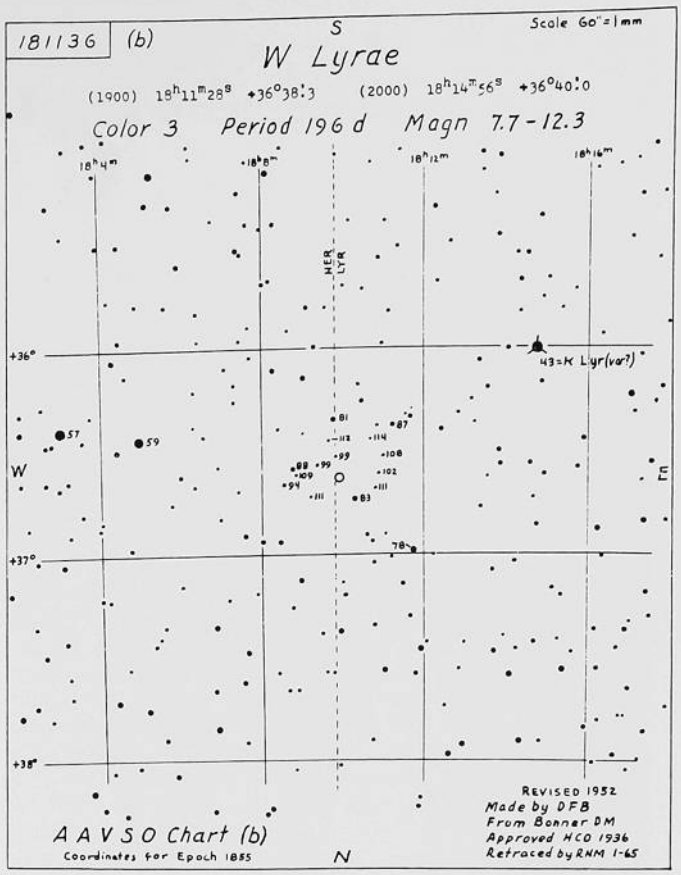
In order to contribute to the program, however, you must use the most current versions of the AAVSO charts. Some of the program stars have had charts of various types in circulation for three-quarters of a century. In that time the magnitudes of most comparison stars have been revised, new comparison stars have been added, and some comparison stars, found to be slightly variable, have been removed from a variable's sequence. Using the most up-to-date charts ensures that all of the observers working together will provide consistent estimates of magnitudes for various stars, minimizing errors. Should you contribute numbers to the data stream for *Hipparcos*, you must be prompt. The AAVSO plans to communicate data to the *Hipparcos* teams within a month of receipt.

Let's take a look at four of the *Hipparcos* stars that will be observable this season. I have chosen two traditional long-period variables and two semiregular variables.

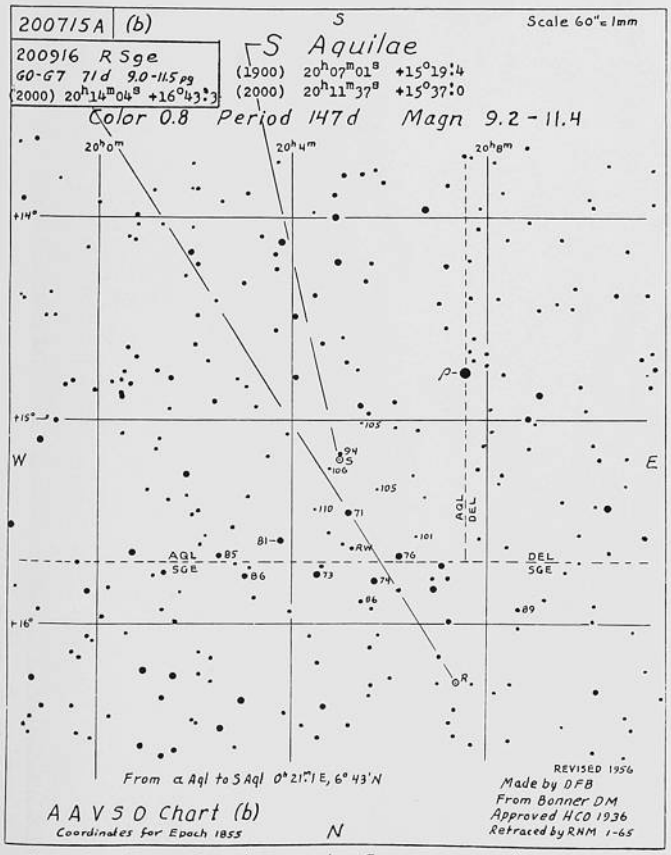
143227 R Bootis. This was the first star in Bootes to be recognized as variable. Its northerly declination means that Northern Hemisphere observers can follow its variation for over half of every year. It has a large range of variation — up to six magnitudes — from a maximum that has gone as high as 6.7 to a minimum that has gone as deep as 12.8, although its average range, according to the third edition of the *General Catalogue of*



The long period variable R Bootis fluctuates between 7.2 and 12.3 over a period of 223 days. Charts courtesy Janet A. Mattei, director, AAVSO.



Another long-period variable, W Lyrae, varies between magnitudes 7.7 and 12.3 over a period of 196 days.



S Aquilae is a semiregular star that fluctuates somewhat unpredictably between magnitudes 8.9 and 12.0.

Variable Stars (*GCVS*), is five magnitudes. The star fluctuates between magnitudes 7.2 and 12.3.

142539 V Bootis. This star is an unusual, semiregular variable. Catalogued in the *GCVS* as SRa, the cycles exhibited by V Bootis are not constant and the star's variation in brightness can become irregular. Briefly, in 1971, V Bootis was constant in brightness. Its maximum magnitude of 7.0 and minimum of 11.3 occur in a period of approximately 258 days. V Bootis is an ideal star for beginning observers because it is easy to find and remains bright enough for easy observation with small telescopes in urban locations. On April 6, 1989, I estimated the star's magnitude at 8.6.

181136 W Lyrae. This long-period variable typically varies over a range of four magnitudes, from 7.9 to 12.2. Its period is about 196 days, which is reasonably short for a long- period star. Extreme maxima have been recorded as high as magnitude 7.3, with minima as low as 13.0. W Lyrae's maxima tend to alternate, with one maxima a few-tenths of a magnitude brighter than the next. I estimated this star's magnitude at 9.6 on April 6, 1989.

200715A S Aquilae. One of Aquila's most interesting variables is a semiregular with a variation that can span over three magnitudes. S Aquilae's maximum is magnitude 8.9 and its minimum 12.0. The star's cycle lasts 146 days, although the range and the period are not entirely predictable.

All long-period and semiregular stars are ruddy in color. Because of this, you must watch out for the Purkinje effect. This occurs when red light builds-up on your retina, causing the stars to appear to brighten as you observe them. Avoid this effect by looking toward and away from the stars in fast glances instead of staring.

Contact the AAVSO's director, Janet Mattei, at 25 Birch Street, Cambridge, MA 02138, for more information on the *Hipparcos* program.

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Scanning the Literature
The Latest Research News
by Brian Skiff

As a special feature under this heading, I would like to provide the actual data compiled from two papers that I feel make significant contributions to the literature. This spring, two lengthy papers containing magnitudes for the central stars of southern planetary nebulae were published. The first paper was written by a European group led by R. Tylenda and A. Acker and was published in the January 1989 *Astronomy & Astrophysics Supplements*, volume 77, page 39. The other paper was written by Richard A. Shaw and James B. Kaler and appeared in the March 1989 *Astrophysical Journal Supplements*, volume 69, page 495.

The list below contains V magnitudes for over two hundred central stars, most never measured in this way before. While many are "obscure" objects, the likes of which Jack Marling is fond of, you'll find many familiar nebulae. The table lists the Perek and Kohoutek catalogue designations based on galactic coordinates, which are listed in *Sky Catalogue 2000.00*, volume 2, and on the *Uranometria* charts. The common identities involving the discoverer's name are also given. The final two columns list the magnitudes from the two papers.

To give some indication of the errors involved, a colon is added when the quoted error is between 0.25 and 0.50 magnitudes for the Tylenda *et al.* data, and between 0.20 and 0.50 for Shaw and Kaler. A double colon indicates errors in both cases greater than 0.5 magnitudes — these are truly approximate values likely to be substantially off. Don't trust 'em!

The two groups used different observing techniques to arrive at these results. Tylenda *et al.* used a photoelectric scanner on a spectrograph, calibrated with standard stars measured in the same way to get absolute fluxes, to record the entire visible spectrum. Shaw and Kaler used an ordinary photoelectric photometer together with a large number of very narrow passband filters, which isolate various emission lines and the continuum light of the nebulae. In both cases the nebular emission is subtracted out of the data using a complicated process; the residuum is assumed to represent the light of the central star alone.

Why do they get different results? Because the results depend on how the nebular light is subtracted out. There are a number of pitfalls in this process because we don't really understand the structure of planetaries, and this affects the models used to derive the central star magnitudes. This is a typical bootstrap problem in astronomy: you try to observe x in order to understand y, but the properties of y affect x, so you can't get results free of ambiguity for either. Isn't science fun?

There is considerable overlap in the stars each group observed and listed in their papers. As you go through the list, notice that the two teams agree when the stars are bright (brighter than V~13-14) but get progressively more discrepant as you go fainter. Both groups indicate that their data are suspect below magnitude 15-16, depending on how bright the surrounding nebulae are. For any given faint star with discrepant magnitudes, they would doubtless agree that both are likely to be wrong — the techniques involved just aren't that sensitive.

In principle, the Tylenda *et al.* data should be freer of problems, but the difficulties just mentioned in interpreting the raw data mean that the two are equivocal. Only further observations with refined techniques (and, probably, bigger telescopes) will lead closer to true measurements. Watch this space . . .

PK Name	ID	Tylenda	S&K
0+12 1	I4634		13.98
0+17 1	PC 12		15.26
0- 2 4	M2-21	14.64	
0- 2 6	M3-19	16.9:	
0- 3 1	M3-22		>17.8
1- 4 1	H1-55		16.57
1- 6 2	SwSt 1	11.8	
2+ 5 1	N6369	16.2	15.56
2- 2 1	H1-45	16.8:	
2- 2 4	M2-23	16.7:	
2- 3 3	M1-37	14.98	
2- 3 5	M1-38	14.42	
2- 4 1	H1-54	15.4	
2- 4 2	M1-42	17.3:	
2- 9 1	Cn1-5	16.6:	
2-13 1	I4776	13.9:	14.47:
3+ 2 1	Hb 4		>17.0
3- 2 3	I4673		17.58::
3- 4 5	N6565		15.88:
3- 4 7	Ap1-12	13.27	
3- 4 8	M2-30	17.1:	
3-14 1	Hb7		13.97
4+ 4 1	M1-25	17.7::	
4-11 1	M3-29	15.55	
4-11 2	He2-418	16.0	
5- 3 1	H1-58	17.4:	
5- 6 1	N6620		16.25:
6+ 2 5	M1-31	18.2::	
6+ 8 1	M1-20		17.1::
7+ 1 2	M3-18		15.34
7+ 6 2	M1-24	15.9	
7- 4 1	H1-65	14.66	
7- 6 2	Vy2-1	17.6::	
8+ 6 1	He2-260	14.25	
8- 1 1	M1-40		18.3::
8- 4 1	M2-39	15.8	
8- 7 2	N6644		15.63:
9+10 1	A41	16.1	16.42:
9- 5 1	N6629	12.94	12.82
9-10 1	M3-33	15.9	
10+18 2	M2-9		15.65
10- 1 1	N6578		15.74
11+ 5 1	N6439		16.10::
11+ 6 1	M2-15		18.2::
11+11 1	M2-13		18.8::
11- 0 1	M1-43	16.0	
11- 0 2	N6567		14.43:
11- 6 1	M1-55	13.99	
11- 9 1	H2-48	13.37	
13+32 1	Sn 1	14.73	14.69
14- 5 1	VV3-5	13.27	
15- 4 1	M1-53	14.50	
16- 1 1	M1-46	12.83	
17- 4 1	M3-30	16.0	
18+20 1	Na 1		16.25
19- 5 1	M1-61	16.8::	
22- 2 1	M1-57	16.3:	
25+40 1	I4593	11.13	
27- 9 1	I4846		15.45:
29- 5 1	N6751	15.44	
31-10 1	M3-34	15.9:	
33- 2 1	N6741	17.6::	
34+11 1	N6572		12.88:
36-57 1	N7293	13.62	
37- 6 1	N6790	15.5:	
43+37 1	N6210	13.7	
45- 2 1	Vy2-2	15.1	14.45
52- 4 1	M1-74	18.1:	
54- 2 1	M1-72	17.6	
54-12 1	N6891	12.44	
58-10 1	I4997	15.4::	

61- 9 1	N6905	15.5	
66-28 1	N7094	13.73	
190-17 1	J320		14.31
194+ 2 1	J900		16.5:
205-26 1	MaC2-1	16.7:	
211- 3 1	M1-6		15.8
212+ 4 1	M1-9		15.5
215-24 1	I 418		10.17
220-53 1	N1360	10.98	
221-12 1	I2165		14.99:
226+ 5 1	M1-16		16.94:
226- 3 1	PB 1		16.0
232- 4 1	M1-11	13.95::	14.07
233-16 1	A 15		16.4
234+ 2 1	N2440		14.24:
234- 0 1	M1-15		13.03
235- 1 1	M1-14	14.09	
235- 3 1	M1-12	14.08	
238+34 1	A 33		>15.66
239+13 1	N2610		15.90
240- 7 1	M3-2		16.96:
242-11 1	M3-1	15.4	15.77
243- 1 1	N2452		16.11
245+ 1 1	M3-5		>17.9
248- 8 1	M4-2		17.0:
254+ 5 1	M3-6	13.9	
258- 0 1	He2-9	16.8:	16.25
259+ 0 1	He2-11		18.92:
261+ 2 1	He2-15		>17.8
261+32 1	N3242		12.10
264- 8 1	He2-7	16.6:	
264-12 1	He2-5	16.4::	14.74
265+ 4 1	N2792		15.74:
268+ 2 1	PB 5		18.67::
274+ 2 1	He2-34	16.5:	
274+ 2 2	He2-35	16.2:	
275- 3 1	He2-25		16.96:
275- 4 1	PB 4		15.916.15
277- 3 1	N2899		>15.9
278- 5 1	N2867	17.3::	15.0::
278- 6 1	He2-26	16.7::	
279- 3 1	He2-36	11.22	11.37
281- 5 1	I2501		14.48:
283+ 2 1	My 60		16.87:
285- 2 1	He2-47	12.96	
285- 5 1	I2553	15.6:	15.51:
285-14 1	I2448	13.94	14.09
286- 4 1	N3211		15.50::
288- 5 1	He2-51	15.60	15.62
291- 4 1	I2621		15.39:
292+ 4 1	PB 8	14.05	13.55
294+ 4 1	N3918		13.24:
294+43 1	N4361		13.18
296- 3 1	He2-73		16.11:
296-20 1	N3195		>15.3
298- 4 1	N4071		19.15:
300- 1 1	He2-85		16.59
300- 2 1	He2-86	18.4::	
304+ 5 1	He2-88	15.26	
304- 4 1	I4191		16.4::
305+ 1 1	He2-90	15.3	16.47::
306- 0 1	Th2-A	14.48	
307- 4 1	MyCn 18	13.9:	
307- 9 1	He2-97	15.4	15.56:
308-12 1	He2-105	15.61	14.73
309- 4 1	He2-99	13.84	>13.5
309- 4 2	N5315	14.3:	13.76::
311+ 2 1	He2-102		17.25:
312+10 1	N5307	14.69	14.58
312- 1 1	He2-107	15.9	15.11
315+ 5 1	He2-109		>18.9
315+ 9 1	He2-104	16.3:	
315- 0 1	He2-111		16.7::
315-13 1	He2-131	11.08	
316+ 8 1	He2-108	12.63	12.83
319+ 6 1	He2-112	17.1::	
319- 9 1	He2-134		13.62
320- 9 1	He2-138	10.83	10.98
320-28 1	He2-434	14.45	
321+ 2 1	He2-115	15.6	16.24
321+ 2 2	He2-117		>17.9
321+ 3 1	He2-113	12.16	
321-16 1	He2-185		16.46:
322- 5 1	N5979	16.7:	15.29
322- 6 1	He2-136	16.6:	
323+ 2 1	He2-123		16.84:
323- 2 1	He2-132		17.04
325+ 4 2	He2-127		16.44:
325-12 1	He2-182	13.33	13.47
326- 6 1	He2-151	13.07	
326-10 1	Cn1-2		13.28
327+10 1	N5882	13.62	13.43:
327+13 1	He2-118	16.1:	18.7::
327- 1 2	He2-140	17.2:	
327- 2 1	He2-142	15.7:	15.15
327- 4 1	He2-147	16.9::	
329+ 1 1	VBRC 7	13.56	
329+ 2 1	Sp 1		14.03
329- 2 1	He2-149	16.l:	
330+ 4 1	Cn1-1	10.83	11.14
331+16 1	N5873	16.4:	15.52:
331- 1 1	Mz 3		16.0::
331- 3 1	He2-162	13.43	
331- 5 1	PC 11	12.67	
332- 9 1	He3-1333	11.38	
334- 9 1	I4642	16.66::	15.66::
336- 5 1	He2-186		16.62
336- 6 1	PC 14		16.51:
337+ 1 1	Pe1-7	17.1:	
337- 5 1	He2-187	12.78	
338+ 5 1	He2-155		16.26:
338+ 5 2	He2-156		13.29
338- 8 1	N6326		15.53:
341+ 5 1	N6153		15.39
341+13 1	N6026		13.29
342+10 1	N6072		18.47::
342+27 1	Me2-1	17.4:	16.03:
343+11 1	H1-1		17.30
345+ 0 1	I4637	12.54	12.47
345- 8 1	Tc 1	11.85	11.38
346- 8 1	I4663		15.16:
348- 9 1	He2-306	16.0:	
348-13 1	I4699		15.26::
349+ 1 1	N6302	16.0:	14.7::
349+ 4 1	M2-4		16.9:
349- 1 1	N6337		14.90
350+ 4 1	H2-1	13.21	13.27
351+ 5 1	M2-5		16.0
352- 7 1	Fg 3		14.3
353+ 6 1	M2-7	13.92	
355+ 3 2	H1-9		15.8
355- 3 3	H1-35	15.3:	
355- 4 2	M1-30	16.3	
355- 6 1	M3-21		15.34:
356- 2 2	M1-27	14.70	14.35
356- 4 2	H1-41	16.1	
356-11 1	Lo 17	16.2	
357+ 3 1	M3-7		16.5
357- 4 1	H1-42	17.2::	
357- 4 2	M2-22	16.4:	
357- 4 3	H1-43	15.53	
358+ 4 1	M3-8		16.7:
358+ 5 2	M3-40		>17.2
358- 0 2	M1-26	12.88	12.61
358- 3 8	ShWi5		16.55
358-5.3	H1-50	16.2:	
358- 6 1	He2-354	13.26	
358- 7 1	N6563		15.38
358-21 1	I1297	16.6:	14.22:
359+ 4 1	Th3-14	15.87	
359+ 5 1	M2-12	14.74	
359- 6 1	H1-62	14.89	
359- 7 1	M2-32	15.7	

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Power your scope with this rechargeable battery pack up to 12 hours. Wt. only 5 lbs. **$65.95**

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FOR DOBSONIAN TELESCOPES OF ALL SIZES

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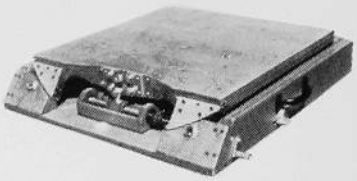

- Full Hour of Precision Tracking
- Quick Rewind

PERFECT FOR:
- Visual Observing
- Group Viewing
- Astro-Photography

A well-made Dobsonian telescope is an excellent observing machine. It features unmatched stability and smoothness of motion. Plus it is eminently compact and transportable. However the Dobsonian has one significant drawback – no motor drive. You have to push it around to follow what you're viewing. This can get to be a hassle.

But set a Dobsonian on an *EQUATORIAL PLATFORM* and experience **INSTANT MOTORIZED TRACKING** – a full hour at a time! Wherever you point, you're tracking – smoothly, precisely – without losing that stability, ease of operation, or portability.

A Dobsonian on an *EQUATORIAL PLATFORM* is the **ULTIMATE USER-FRIENDLY TELESCOPE.**

SIZE OF DOBSONIAN	SINGLE-AXIS PLATFORM	DUAL AXIS PLATFORM
12-14"	$ 825.00	$ 1125.00
16-18"	$ 975.00	$ 1425.00 *Plus*
20-22"	$ 1275.00	$ 1725.00 *Shipping*
24-26"	$ 1875.00	$ 2425.00

— Send $2.00 for fully illustrated brochure with color photo —
Platform parts and drive components available for telescope makers.
— Ask for free parts price list —

Does Your Telescope Have The Shakes?

Frustrated at long waits for the field of view to steady after repositioning or focusing? A dramatic solution is now available...

Introducing SHAKE-ENDERS

These remarkable foot pads will eliminate up to 80% of the image vibration found in portable telescopes. Made with a patented space-age dampening material encased in a cast aluminum cup, SHAKE-ENDERS are not only VERY effective in cutting vibration but are durable in the field. Increase your telescope's performance in the most obvious way! Stabilize with SHAKE-ENDERS!

THEY WORK! ..... $59.95 + applicable tax & $3.00 shipping
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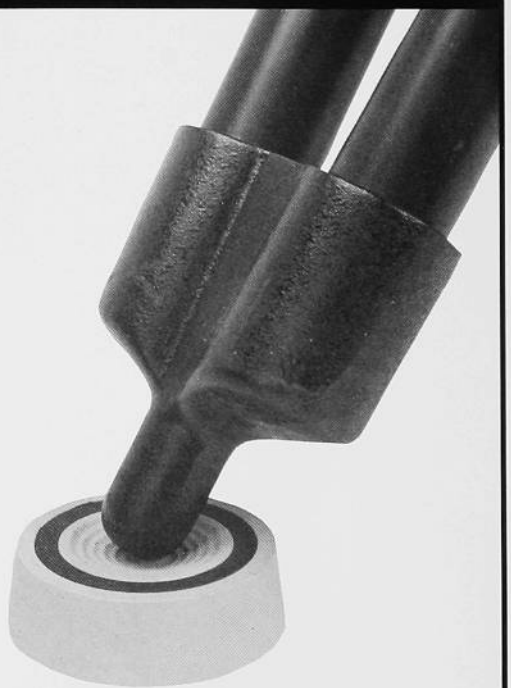


SHAKE-ENDER foot pad shown supporting Celestron® tripod leg.

LUMICON

HIGH PERFORMANCE TELESCOPE PARTS

LUMICON® SKY VECTOR™- *NEW!*

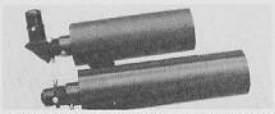
Computer-Controlled Digital Setting Circles, from $498

Incredibly Smart!
thus
Incredibly Easy!

- Digital right ascension readout to 1 minute of R.A.
- Digital decl. readout to 10 arc-min
- Digital altitude readout to 1°
- Polar alignment **not required!**
- Just sight two stars!
- Works for alt-azimuth **and** equatorial mounts

LUMICON Sky Vector™ (state scope) **$498**
Sky Vector™ Kit (you supply hardware) **$469**
Pair digital shaft encoders (for 2nd scope) **$135**

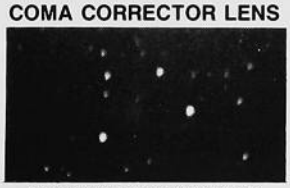
LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers perfer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F = 300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F = 500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle **$89.50**
1¼" straight-thru 80mm SUPER-FINDER **$169**
1¼" right-angle version, w/star diagonal **$195**
2" right-angle version, non-rotating focuser **$199**
1¼" Deluxe right-angle Super-Finder **$279**
2" Deluxe right-angle Super-Finder **$309**
25mm Cross-hair 1¼" eyepiece (12X) **$29**
1¼" Star Diag . . **$32**, 2" Star Diag., silver, . . **$145**
1¼" Amici Prism diag. for correct left-right views **$59.50**

COMA CORRECTOR LENS



Coma 1 inch off-axis (17½" f/4.5)

Same Field with LUMICON coma corrector lens; note smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener
2" lens **$285.00**
Extension tube for viewing **$26**
2" Easy-Guider™ (state camera) . . **$169.50**

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For phone orders please call (415) 447-9570
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Foreign orders add $8 ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.

NEW! ENCHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**
4.25" **$149.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.
1¼" (1.32" mirror) **$89.50**
2" (1.83" mirror)(see photo above) . . **$145.00**

OXYGEN-III FILTER

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™ Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	**$99.50**	**$199.50**
Lumicon UHC	**$99.50**	**$199.50**
Lumicon Deep-Sky	**$79.50**	**$119.50**
Set UHC and Oxygen-III .	**$190.00**	**$380.00**

NOTE: The Oxygen-III Filter is not a substitute, but a compliment to the UHC Filter. **1 year guarantee:** You must see nebulae with the O-III filter that are **invisible** without a filter.

NEW ADJUSTABLE PIGGYBACK MOUNT

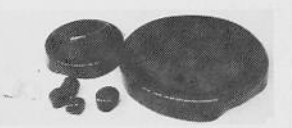
LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc., but is ideal for any telephoto lenses or small telescopes.

Deluxe Piggyback Mount **$45.00**
(State Telescope Type)
LUMICON 12x80mm SUPER-FINDER . **$170**

NEW! LOW PROFILE HELICAL FOCUSERS

LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.
Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.
LUMICON 1¼" Helical Focuser **$49.50**
LUMICON 2" Helical Focuser **$59.50**
LUMICON Non-rotating Helical Focuser **$79.50**
3 handles (see photo) for non-rotat. focuser **$12.95**
2"/1¼" adapter w/48mm filter threads . . **$20.00**
2" LUMICON EASY-GUIDER **$169.50**

PROTECTIVE DUST COVERS



Protective plugs (left), vinyl dust covers.
Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser . . . . . **4/$2**
2" O.D. plug . **2/$2** 3½" O.D. plug **$1.50**
1¼", 1⅜" . . . . **3/$2** 7½" **$8**
1½" . . . . . **2/$2** 9½", 10.4"* . . . **$12**
2" . . . . . **2/$2** 12½", 12⅞"* . . **$15**
3½", 4½" . . . . . **$5** 16"* **$20**
5½" . . . . . **$6** 19" (DS-16) . . . **$27**
*Fits Odyssey

MAKE YOUR OWN ASTROGRAPH

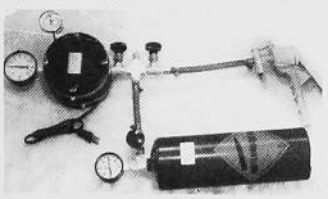
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295.00**



MODEL 600 HYPER-KIT (See Photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller **$595.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms of bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent #4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$79.50**
Illuminated reticle eyepiece system . . **$79.50**
Guider for Hasselblad **$350,** Mamiya 645 **$159**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation —3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad $185, Mamiya 645 **$159**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

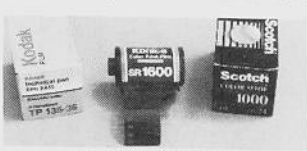
GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) . . . . . **add $99.95**
Adapter for Hasselblad adapter **$195,** Mamiya 645, **$96**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$79.50**
Lumicon 12mm eyepiece system has adjustable L.E.D. illumination, dual crosslines, battery pack.

2. Cable release for long exposures . . **$9.95**

3. **LUMICON Quartz Drive Corrector** . **$219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination motor (state telescope) . . **$70**
NEW Deluxe Digital Qtz. Drive Correc. **$298**



HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR3200, fastest of all, color neg	24	**$13.95**
Konica SR400, fine gr. color neg	12	**$10.95**
3M 1000, fastest slide film	20	**$12.95**
Fujichrome RD100, fine gr. slide	24	**$12.95**
5072, color slides from negs	36	**$6.95**
D-19 B&W Developer	1 gal.	**$6.95**

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All ***GALAXY OPTICS ULTIMATE IMAGE™ MIRRORS*** are thoroughly tested throughout each stage of completion and are totally hand-figured and null tested to assure you of a professional quality paraboloidal optic.

GALAXY'S ULTIMATE IMAGE™ full thickness (1:6) and lightweight mirrors (2.00") are made from Precision annealed *molded* Pyrex mirror blanks and are available with a choice of two outstanding reflective coatings.

COATING #1: 88% Reflectivity - Aluminized and quartz overcoated
COATING #2: 96% Reflectivity - Broadband multilayer dielectric coating over aluminum

FULL THICKNESS 1:6 OPTICS

MIRROR	COATING #1	COATING #2
10"	$ 375	$ 425
12.5"	525	600
16.0"	1700	1950
18.0"	2300	★
20.0"	3400	★

LIGHTWEIGHT 2.00" THICKNESS OPTICS

MIRROR	COATING #1	COATING #2
14.5"	$ 850	1050
16.0"	1100	1350
18.0"	1300	★
20.0"	1650	★
22.0"	2970	★
25.0"	4950	★

GALAXY'S ultra-lightweight mirrors (1.6") are made from fine annealed Pyrex mirror blanks and are manufactured to the same specifications as our 1.6 mirrors.

ULTRA-LIGHTWEIGHT 1.6" OPTICS

MIRROR	COATING #1	COATING #2
14.5"	$ 725	$ 925
16.0"	950	1200
18.0"	1100	★
20.0"	1400	★
22.0"	2450	★

★ Enhanced aluminum coatings by special request only.

ULTIMATE IMAGE™ ELLIPTICAL DIAGONAL FLATS
LASER QUALITY - TRUE 1/10 WAVE FLATS
1/10 WAVE, 20/10 SURFACE QUALITY - GUARANTEED

MINOR AXIS	COATING #1	COATING #2
2.1"	$ 75	$100
2.6"	75	100
3.1"	95	120
3.5"	265	300
4.0"	285	325
5.0"	425	475

All mirrors are available in many popular focal ratios. Full thickness (1:6) and ultra-lightweight Zerodur® Optics available. Mirror refiguring services, write for quotation. For a complete product catalog mail $1.00 to:

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At Last! A product that allows dark adaptation under any condition — daylight, dusk or artificial lighting. A red lens goggle — ASTROGOGGLES allows you to dark adapt and prepare for viewing under normal white light conditions since only red light reaches the eyes.

No more waiting to dark adapt for viewing those faint celestial structures. Step up to your scope ready to observe. No more interrupted viewing from car headlights or from trips into the house for your favorite beverage. No more fussing at (or by) the family for "**Lights out**" when you come back in the house to find a chart.

Second to total darkness, ASTROGOGGLES are the best answer to sensitizing your eyes to far flung photons. Listen - these things work! So lengthen your effective viewing nights and order a pair.

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Total _____

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SUPER LOW-PROFILE(9mm)
T-to-T COMPOSING RING
Rotate your camera without affecting focus!
Highly recommended for use with Spectra Shutter and low-profile off-axis guiders... $34.50

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LOW-PROFILE
VIBRATION-FREE SHUTTER
When that cloud or plane or satellite crosses the field, *temporarily interrupt exposure instead of losing the photo!* (specify 2" or T-thread connection to scope and/or guider)... $97.50
Both 2" & T, add $20.

Duo-View™

QUICK-RELEASE PARFOCAL
ASTROPHOTO & VISUAL
1.25" and 2" SYSTEM

Easy to use & *Economical*
Works with all of your off-axis guiders, eyepiece projection units, and T-adapters!

Uses the light gathering ability of your scope to center-up and compose astrophotos as you *see exactly what your camera will aim at!*...or just enjoy *visual observing without changing the camera focus!* Adapter (included) accepts all of your 1.25" and 2" diagonals and eyepieces.

Duo-View
For current SureSharp owners, or when ordering *with* a SureSharp... $64.50
For use without SureSharp (requires CustomConnector-specify 35mm camera brand & model...$84.50
Off-axis guider, 1.25" right-angle, and eyepiece shown are not included.

With Duo-View use
THE PROVEN PERFORMER
SureSharp™

NEW!
Right-Angle
(works with all SureSharp models)
$39.50

"After all the effort put in to getting the correct exposure, now with SureSharp I don't worry about whether my astrophotos are in focus...what a relief!
BRIAN SKIFF- RESEARCH ASTRONOMER

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Cambridge University Press

The Guide to Amateur Astronomy
Jack Newton and Philip Teece

This guide introduces all the fundamentals of astronomy with an emphasis on practical techniques. Newton and Teece provide an in-depth exploration into the field of astrophotography detailing techniques ranging from simple tripod photography to cold camera photography.
1989 / 327 pp. / 34028-4 / Hardcover $24.95

Pathways to the Universe
Sir F. Graham-Smith and Sir Bernard Lovell

This illustrated introduction to astronomy starts from a level of common experience and develops the subject to the frontiers of modern research. The book explains how to become an astronomer and how to find your way around the sky using simple binoculars, telescope, or the naked eye.
1989 / 239 pp. / 32004-6 / Hardcover $24.95

The Cambridge Atlas of Astronomy
Second Edition
Edited by Jean Audouze and Guy Israel

The most comprehensive and authoritative astronomy reference available, this invaluable guide is intended for amateur astronomers as well as anyone with a deep interest in space research and astronomy. It includes the 1986 appearance of Halley's Comet; 1986 Voyager space probe encounter with Uranus; 1987A Supernova; and information on the newest telescopes.
Approximately 1100 photographs and illustrations / 350 color and 420 black-and-white photographs from the world's most prestigious observatories / 330 color diagrams / 47 tables / 3 star maps
1988 / 432 pp. / 36360-8 / Hardcover $90.00

A Manual of Advanced Celestial Photography
Brad Wallis and Robert Provin

Written by two experts in both the practice and theory of astronomical photography, this unique technical handbook for amateur astrophotographers includes a detailed discussion of topics never before examined in a general survey.
1988 / 400 pp. / 25553-8 / Hardcover $39.50

Observing Variable Stars
David Levy

Written by an award-winning astronomer, this book provides a comprehensive introduction to the field of variable star observation for the amateur. All the major variables are described and classified. Contains a seasonal guide to the night sky usable in all latitudes and includes practical observations.
1989 / 198 pp. / 32113-1 / Hardcover $19.95

Astrophotography for Amateurs
Michael Covington

Amateur astronomers and photographers will enjoy this beautifully illustrated guide to taking pictures of the stars, planets and other astronomical objects using readily available equipment.
1985 / 224 pp. / 25391-8 / Hardcover $32.50

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